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This research concerns building and using a new workstation that integrates lensless, low-resolution images of an entire specimen of human tissue with lensed, high-resolution images of selected regions within the specimen. Two workstations were built in FY95 and are currently on field trial at the Mayo Clinic Scottsdale and Luke Air Force Base (two pathologists each). Their study is double blind and will produce diagnostic reliability data on the workstation. A more compact workstation has been designed and is being built by Optical Systems Corp. for delivery in FY 1997. Related research on improving the resolution of lensless microscopy funded by the NSF has been so successful that we are now recommending rebudgeting so that NSF results are incorporated in existing workstations. Funds are available as Loral (now Lockheed Martin) has lost interest in our funding that was allocated for merging our workstations with their MDIS system in San Antonio. This is fortuitous for another reason. DARPA would like to see our demonstration project done in Washington in preference to San Antonio. Finally this report reviews digital image databases for pathology and current hospital information systems. (Our FY 1995 Annual Report reviewed Pathology Information Systems.)

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FOREWORD

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____ In the conduct of research involving hazardous organisms, the investigator(s) adhered to the CDC-NIH Guide for Biosafety in Microbiological and Biomedical Laboratories.

Kendall Preston Jr. 10/31/96

PI - Signature Date

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1. INTRODUCTION

This is the Fiscal Year 1996 Annual Report for grant DAMD-94-J-4500 (Dual-Use Telemedicine Support System for Pathology) for USAMRMC (U.S. Army Medical Research and Materiel Command). The report covers the use and application of a novel workstation for pathology that integrates both lensless and lensed imaging of surgical pathology specimens mounted on standard microscopy slides. The research reported here is being conducted in parallel with National Institutes of Health grant 5 R44 GM44420-03 entitled "Image Handling System for Pathology and Telepathology." The research involves the use of two workstations built under the USAMRMC grant in a telepathology experiment where one workstation is currently operating at the Mayo Clinic (Scottsdale, Arizona) and the other at Luke Air Force Base (Litchfield Park, Arizona). This project has been under the direction of Lane Garrett of Scottsdale who has served both as a employee of the Kensal Corporation and as an independent consultant. This research has involved not only Mr. Garrett but also Drs. Louis Weiland, Kevin Leslee, Hermilando Payen, and Felix Mamani. These pathologists have produced a protocol for the experiment and are carrying out a double-blind study that will compare the performance of telepathology with ordinary manual microscopic pathology for a selected group of about 50 microscope slides. A report on this study will be made in our final report upon completion of the research.

As regards research, finding ourselves with a few hundred digital images (both lensless and lensed) of surgical pathology specimens, the Kensal staff has been investigating methodology for generating not only a database but also a "Virtual Microscope" that is simply an elaborate digital recording on CD-ROM that can be employed by the computer user to simulate use of the L/L Microscope (Lensed/Lensless Microscope). Copies of this CD-ROM have been distributed to several interested parties and, of course, the Advanced Research Projects Agency.

This FY 1996 Annual Report is divided into five sections as follows:

- Section 1 (this section)
- Section 2 - This section gives both the protocol for the double-blind study commenced between Mayo Clinic and Luke Air Force Base in early calendar 1996. Because of malfunctions of the workstation at Luke Air Force Base, the exact completion date is uncertain and is now estimated as taking place in the first calendar quarter of 1997.
- Section 3 - In order to design the CD-ROM format called the "Virtual Microscope" an extensive survey was conducted of other CD-ROM databases of surgical pathology images developed both by government laboratories, academic institutions, and grantees such as our corporation.
- Section 4 - Since the eventual interface between the workstations and the hospital will be with a HIS (Hospital Information System), HIS's developed nationwide were surveyed. This section documents our findings. Note that in the first annual report similar documentation was provided for pathology information systems.
- Section 5 - A major event occurred during FY 96 that will impact all of our future research. This was the successful culmination of research under National Science Foundation grant DMI-9460231 (Research on Lensless Microscopy). As of September 1996, Kensal had in its laboratory the first new high resolution lensless scans using the state-of-the-art fiber optics combined with the latest high-resolution silicon-based linear detector arrays. As of only a short time ago we were able to digitize full coverslip images at 20 thousand picture points per square millimeter. This compares with a pixel density of only 6 thousand pixels per square millimeter in the current workstations. This, we believe, now solves the problem that lensless images appeared "fuzzy" to some pathologists to the extent that they were unable to identify regions of interest in those scans. This remarkable achievement under the NSF grant makes all current

workstation obsolete. We are therefore suggesting that funds available for FY 97 be reprogrammed, not to build more workstations but to retrofit the existing workstations. Therefore this section presents a new budget and justification thereof.

2. LUKE / MAYO 1996 TELEPATHOLOGY STUDY

The telepathology study between the Luke Air Force Base and the Mayo Clinic commenced in early 1996 and is continuing.

2.1 Protocol

The proposed double-blind telepathology study will use a minimum of 25 cases from the US Air Force Hospital at Luke AFB, Litchfield, AZ and a minimum of 25 cases from the Mayo Clinic, Scottsdale, AZ. The cases will include a broad sampling across organ groups. (No blood smears or Pap smears are to be included.) A cardboard template will be provided that shows the current guide image boundaries of the workstation. Microscope slides that have tissue outside this "view area" should not be used in the study. A separate protocol is being prepared by Kensal to describe recording data in a database. Kensal will be responsible for the compilation and analysis of the data and the final written report.

1. In the first step, Luke AFB will select a minimum of 25 pathology cases that have been previously diagnosed and represent a broad but typical cross section of work at Luke. Each case and slide will be given a unique six digit number starting with "1" (signifying Luke) as the most significant digit. Traceability to the accession number will be held only at Luke in a separate log by Maj. Cooper as the cognizant individual. The new case and slide numbers and other pertinent data (to be determined) will be placed in a spread sheet format by staff of the Kensal Corporation. The second and third most significant digits "xx" will sequentially keep track of each case. A case may have multiple slides with consecutive numbers using the two least significant digits "yy". The fourth position "z" is presently reserved for future use. For example, 1xxz01 will indicate the first slide in case "xx".

   Initially, Luke will play the role of the "remote user" and take guide image(s) that will be transmitted to Mayo. Hi-mag images will then be taken by Luke as requested by Mayo. The reviewing pathologist(s) at Mayo may request additional hi-mag images after examining the initial image(s). Additional information may be requested and provided by Luke as appropriate. A number of iterations may take place for hard to diagnose cases.

   A mutually acceptable number of cases will be handled weekly to keep the work load at a reasonable level. Upon suitable notice, Kensal personnel will be made available to assist as needed.

2. Maj. Cooper, as the cognizant individual at Luke, will then assign new six digit numbers (with the most significant digit assigned a value of "2") for each case and slide used in step 1. The renumbered slides will be forwarded to Mayo for diagnosis using the TSS in "local mode", i.e., using the TSS as a self-contained instrument without any ISDN transmission.

3. In a third step, the renumbered slides will be analyzed at Mayo in the normal visual manner, i.e., without using the TSS. If time permits and staff is available, the same glass slides will be reviewed by a "panel of experts" at Mayo using normal visual diagnosis. If there is any disagreement with a diagnosis from steps 2 and 3, the reason(s) are to be ascertained, if possible, for the purpose of finding how the methodology can be improved.

4. In a like manner Mayo Clinic will play the role of the remote user and go through the above steps 1 through 3 with 25 or more of their cases. Six digit numbers for each case will be assigned by Dr. Weiland beginning with "3" as the most significant digit. Luke will then perform the role of "expert" pathologist. New numbers beginning with a "4" as the most significant digit will be issued when the actual glass slides (chosen by Mayo) are sent to Luke for both TSS local mode (step 2) and normal (step 3) analysis. For step 3, since there are insufficient pathologists to form a "panel," perhaps, AFIP would consent to participate by forming a panel.

2.2 Problems with Workstations Installed at Luke AFB and Mayo Clinic

- Work is required on the enhancement of contrast and color fidelity of the guide images to permit satisfactory selection of regions-of-interest (ROIs) for higher magnification images.
- There is an intermittent problem of the Video Relay sticking in the camera mode stage.
- The positioning of numerous guide image scans varies over time.
- The guide images deteriorate until they become unusable. Both the new and old software have been tested with the same results.
- Serious low amplitude oscillations develop which can only be stopped by "damping" the stage with slight hand pressure on the edge of the stage.
- Various amounts of both horizontal purple and yellow lines and vertical lines of discoloration appear usually several tenths of a mm wide.
- The focus control needs work. As it now is programmed, the operator frequently overshoots the focus point and has a hard time coming back, especially at 20x and 40x.
- There is much difficulty navigating when in Windows NT.
- The monitor screen tends to drift slightly in size and position requiring realignment with the touch screen grid.
- When "Quit" is accidentally activated, the whole session aborts.
- The stage is unstable when jumping to high-magnification positions.
- When in Stand-alone Mode and the Guide image is scanned and brought to the screen, there is no provision for recording a message with the Guide image.
- In the Dual Mode of operation, the sending station can add comments to the Guide image file and receive back any comments that the receiving (expert) station has made on the high-magnification images; however, the comments are apparently not recorded with the high-magnification images that are saved at the expert station.
- In the Single Station Mode, it is possible to jump around the viewed locality when in the "Get Hi-Mag" function. A problem arises in that there appears to be a finite number of times that this can be done before "crashing" and losing the whole session on that case.
- When viewing the next high-magnification images, the doctor may start dictating shortly after it opens. The image number, magnification and position are updated very slowly sometimes causing the doctor to pause for the update.
- After a period of multiple scans, the whole guide image shifts left and does not correct itself.
- In the "Local Mode" the system has a limitation of approximately 16 "jumps" before it crashes.
- Inability to go back and review high magnification images that have been saved and record additional comments is a problem.
- The guide images lack some contrast unless the slides are very good initially.

- Some kind of backup capabilities should be built into the TSS1 software and automated.
- The Mayo workstation is consistently showing a warp between rows K & J with displacement to the left.
- The Mayo system exhibited significant height distortion.
- When in the "Local Mode" it is easy to forget to record the Guide image. In the "Dual Station Mode" the opposite problem can occur where the guide image can get saved twice.
- It would be useful to be able to selectively erase the green squares on the guide image that show the ROIs (Regions of Interest) such that the guide could be rescued without clutter.
- Occasionally memory errors occur for no apparent reason.
- The current sound cards are unacceptable for any production work.
- Still experiencing problems when recording audio for a given image. If the operator does not hit the stop or half button just right, the record window jumps behind the TSS1 window and keeps the recorder running. The TSS1 program assumes that recording has stopped and allows the operator to go on to the next image. A second recording window will then come up when the operator wishes to record but will only function for about one section then it seems to lock up. The only recourse is to abort the whole session, go to Windows NT where the first window shows the recording continuing and stop the recording.
- Problems occur when transmitting requested high-magnification images from Luke to Mayo. The error messages "Unable to transmit request file" and "Memory could not be written" occur several times. High-magnification images are lost.
- Unable to play back the original history and comments without having to reload the original guide image when receiving previously requested high-magnification images back from the transmitting site.
- Coordinates on the guide image are off according to the actual high-magnification being observed.
- The damping coefficients or stage characteristics seem to change with time and/or usage.
- When trying to do the first downloads to the SyQuest drive were unsuccessful, patterns were observed that sometimes plaque the scans of the guide images. This indicates that the noise dots are related to the scan sync and/or the phase-locked-loop.
- Operating in the "Local Mode" and starting to do a diagnosis going through requested high-magnification images from 2/11 through 11/11, the system jumped back to image 2 when going from high-magnification image 9 to 11.
- Two pixels are dead on the Luke LDA.
- After a telepathology session, it is hard to know what was actually completed successfully since there is no status information or receipt of document information.
- The 2 MB hard drive fan on the Luke workstation has developed a noise and needs to be replaced.

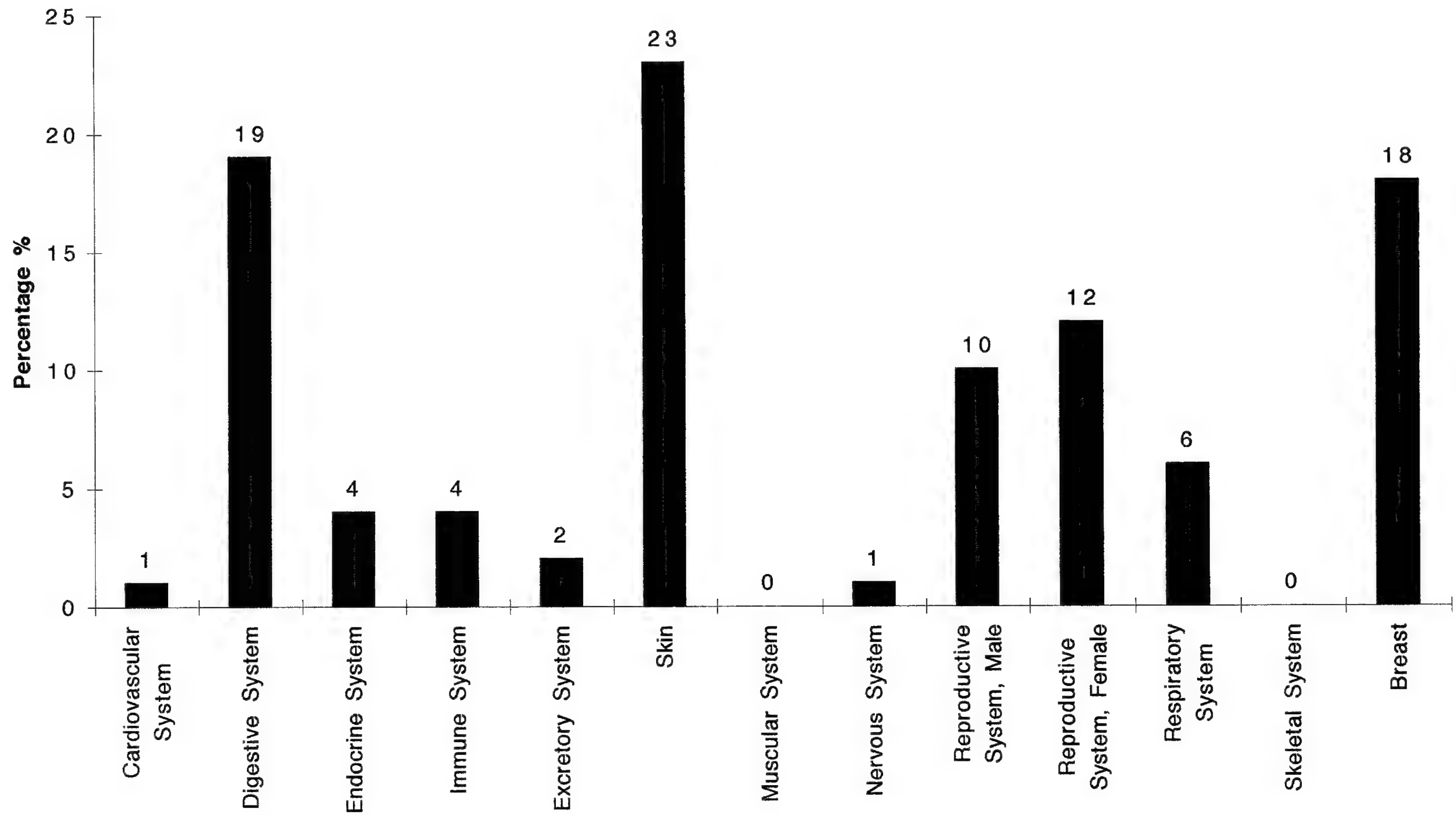
2.3 Tabulation of Microscope Slides Under Study

Table 1 contains information regarding the Luke Air Force Base / Mayo Clinic Telepathology Experiment including slide history and status as of October 15, 1996. This data has been added to the organ systems histogram (Chart 1) for slides done only between Kensal and the Mayo Clinic prior to the installation at Luke AFB that occurred in mid-1996.

Table 1 - Luke/Mayo Telepathology Slide History and Status; 11/1/96

Mayo Cases	Luke Cases	Local Mode Done	Sent To Kensal	Cleared Out	New #	Dual-mode Im. Sent	Hi Mags Requested	Hi Mags Sent	Dual Mode Diagnosis	Sent to Kensal	Cleared Out	Comments
		Dr. Weiland			Dr. Weiland to Luke		Dr. Payen					
501000		7/16/96	7/24/91	8/16/96	501000	8/16/96	33838					Requests
502000		7/16/96	7/24/91	8/16/96	502000	8/16/96	33838					8/27/96
503100		7/16/96	7/24/91	8/16/96	503100	8/16/96	33838					Requests
504100		7/16/96	7/24/91	8/16/96	504100	8/16/96	33838					Requests
505000		7/17/96	7/24/91	8/16/96	505000	8/16/96	33838					Requests
506000		7/17/96	7/24/91	8/16/96	506000	8/16/96	33838					Requests
507000		7/17/96	7/24/91	8/16/96	507000	8/16/96	33838					Requests
508000		7/17/96	7/24/91	8/16/96	508000	8/16/96	33838					Requests
509000		7/17/96	7/24/91	8/16/96	509000	8/16/96	33838					Requests
510000		7/17/96	7/24/91	8/16/96	510000	8/16/96	33838					Requests
		Dr. Weiland			Dr. Leslee to Luke							
511100		8/26/96	8/27/96	8/26/96	511100	8/28/96						
512100		8/26/96	8/27/96	8/26/96	512100	8/28/96						
513000		8/26/96	8/27/96	8/26/96	513100	8/28/96						
514000		8/26/96	8/27/96	8/26/96	514100	8/28/96						
515000		8/26/96	8/27/96	8/26/96	515100	8/28/96						
516000		8/26/96	8/27/96	8/26/96	516100	8/28/96						
517000		8/26/96	8/27/96	8/26/96	517100	8/28/96						
518000		8/26/96	8/27/96	8/26/96	518100	8/28/96						
519000		8/26/96	8/27/96	8/26/96	519100	8/28/96						
520000		8/26/96	8/27/96	8/26/96	520100	8/28/96						
	Drs. Payen, Mamani				Dr. Payen to Mayo		Dr. Weiland	Dr. Mamani	Dr. Weiland			
	601000	7/30/96	8/7/96		601000	8/16/96	8/16/96	33834	8/23/96			Lost some
	602000	7/30/96	8/7/96		602000	8/16/96	8/16/96	33834				Re-Request
	603000	7/30/96	8/7/96		603000	8/16/96	8/16/96	33834				Lost some
	604000	7/30/96	8/7/96		604000	8/16/96	8/16/96	33834				Re-Request
	605000	8/7/96	8/7/96		605000	8/16/96	8/16/96	33834				Lost some
	606000	8/7/96	8/7/96		606000	8/16/96	8/16/96	33834	8/23/96			Re-Request
	607100	8/7/96	8/7/96		607100	8/16/96	8/16/96	33834				Lost some
	608000	8/7/96	8/7/96		608000	8/16/96	8/16/96	33834				Re-Request
	609000	8/7/96	8/7/96		609000	8/16/96	8/16/96	33834				Lost some
	610000	8/7/96	8/7/96		610000	8/16/96	8/16/96	33834				Re-Request
		Dr. Mamani			Dr. Payen to Mayo		Dr. Leslee					
	611000	8/19/96	8/23/96		611000	8/16/96	9/5/96					
	612000	8/19/96	8/23/96		612000	8/16/96	9/5/96					
	613000	8/19/96	8/23/96		613000	8/16/96	9/5/96					
	614000	8/19/96	8/23/96		614000	8/13/96	9/5/96					
	615000	8/19/96	8/23/96		615000	8/13/96	9/5/96					
	616000	8/19/96	8/23/96		616000	8/13/96	9/5/96					
	617000	8/19/96	8/23/96		617000	8/13/96	9/5/96					
	618000	8/19/96	8/23/96		618000	8/13/96	9/5/96					
	619000	8/19/96	8/23/96		619000	8/13/96	9/5/96					
	620000	8/19/96	8/23/96		620000	8/16/96	9/5/96					

Chart 1 - Organ Systems Histogram



3. A REVIEW OF DIGITAL IMAGE DATABASES FOR PATHOLOGY

This section is the text of a review paper that is being prepared for submission to the College of American Pathologists.

During the past decade, physicians have witnessed dramatic advances in computer technology. The rapid development of video and computer based communications of medical information has now made it possible for a physician to examine a patient in a remote location. The support for digitized examinations in radiology is quite extensive, however, this kind of support has been lacking in the field of pathology. In fact, the dynamics of gross and microscopic pathological exams have remained basically unchanged in the last century. Pathologists when looking through the eyepieces of their microscopes, still find inverted images of only a small portion of the specimens to be analyzed.

Modern laboratories have indeed begun to utilize computers, but mainly for the management of text. Today telepathology systems do exist which afford the means to transfer pathological reports and provide verbal communication links between pathologists. Yet the image more than the written word drives diagnostic decisions. The truth is that very few systems have the capability of handling images. In order to bring pathology into this era of high technology, images must be created and stored in a digital format.

Many significant benefits could evolve from the use of digitized microscopic images. These images may be used to aid in diagnostic efforts, to serve as educational resources, and to facilitate communication between pathologists. Being able to view an image over a communications network would reduce referral time from a remote pathologist by eliminating the need to transfer the glass slide. Images organized to form a digitized atlas of surgical pathology could serve to lessen the time a pathologist spends consulting reference books and other pathologists. Medical students would also benefit greatly from computer-assisted training technology, especially considering the vast accumulation today in digital image databases.

3.1 Current Status of Telepathology

A problem exists with ordinary microscopy in that a pathologist is only able to see a minuscule portion of the coverslip even when using the lowest power objective lens (2x). The Kensal Corporation is currently working to resolve this problem through the development of a telepathology workstation which will integrate Kendall Preston, Jr.'s patented "lensless microscopy" with lensed full-color imaging (U.S. Patent 4,777,525). "Lensless microscopy" enables a pathologist to capture and display on screen an image of the *entire* coverslip of a glass slide. This image is referred to and essentially used as a "guide image." The workstation is unique in that it can register and integrate each full-coverslip scan with the high magnification images taken from the corresponding coverslip. Coordinates of each high magnification are automatically recorded. This enables the pathologist to return to the high magnification images at the exact locations requested.

In 1994, the Defense Advanced Research Project Agency (DARPA) granted monies to Kensal Corporation to build and test telepathology workstations that integrate lensless full-coverslip scanning with lensed imaging. In 1996, telepathology field trials were conducted in Arizona with these workstations between Mayo Clinic of Scottsdale and Luke Air Force Base in Litchfield Park. Guide images were produced at the "host" station and sent to the referring pathologist at the second station over ISDN (Integrated Services Digital Network) lines. The referring pathologist used this image as a "global reference" to select regions of interest to be magnified. Once this was completed, the magnified images were sent back to the host pathologist and high magnification images were produced with a Sony color camera mounted on top of a Nikon microscope. The high magnification images were transferred back to the referring

pathologist and one of two paths was selected: either a diagnosis was rendered or the remote pathologist requested more high magnification images. Dictation and annotation could be included while viewing each image. Correct diagnoses were made for almost every tissue sample tested.

The telepathology workstation, now formally called the TSS1, organizes the images and sound files in a digital image database used to record, store, and manage the results of each examination. From the field trials, Kensal Corporation has produced a collection of images, including both the full-coverslip images from the lensless scanner and the high magnification images produced from the lensed, high magnification camera. This data set is unique because it utilizes two registered imaging technologies. To date, Kensal has accumulated a library of approximately 300 images.

3.2 Other Collections of Pathology Images

The production of this unique database and imaging system has led Kensal to look at other databases available to pathologists and medical students to assess their function and compare how different areas are covered. Several other institutions, ranging from academic to government, have begun handling images in digital formats, forming atlases and databases along the way that can be used as references for pathologists and as educational tools for medical students and residents. Whether in the form of an optical disk or a file on the Internet, we have found this information to be useful and easy to access.

The following is an illustrative review of some digital image databases available for pathology. This selection of CD-ROMs represents some of the most comprehensive collections of digitized images of microscopic tissue available. There are a variety of other CD-ROMs on the market as well which serve as electronic references for other pathological disorders, including hematology, cytology, gynecological, ophthalmic, and orthopedic pathology, however we were unable to include all of them in this review.

The six image databases profiled were chosen from four different areas: Academic (University of California at San Diego and the University of Utah), Government (the Armed Forces Institute of Pathology), commercial (Chapman & Hall and Mosby Multimedia), and military subcontract (Kensal Corporation for the U.S. Army Medical Research and Materiel Command).

3.3 Educational Image Databases

Many schools are now beginning to realize what a powerful educational tool image databases can be for resident and medical student training. The University of California, San Diego has developed a database called MedPics that is now commercially available from Micron BioSystems (Denver). MedPics is a computer-based image delivery system with supporting text fields and on-screen graphics to assist in lessons on normal and abnormal structures and functions of the organs. It has been used as an integral part of the Human Disease Course at UCSD since 1992.

Currently, MedPics contains just over 600 images, including gross and microscopic examinations, x-rays, diagrams, and electron micrographs. You may choose to view images from ten different organ systems catalogued under either "Pathology" or "Histology" (Figure 1-b). The section titled "Hematology" is expected to appear in next year's Version 2.0.

Viewing a slide set is as easy as clicking on the system's icon (Figure 1-c) which takes you to a brief overview of the images available in that category (Figure 1-d). You can then page through the images which are accompanied by an informative title, a list of identifying features, as well as a pathological report. The report typically includes information on the specimen such as the preparation and staining, the magnification used, any pathological findings, clinical pathologic

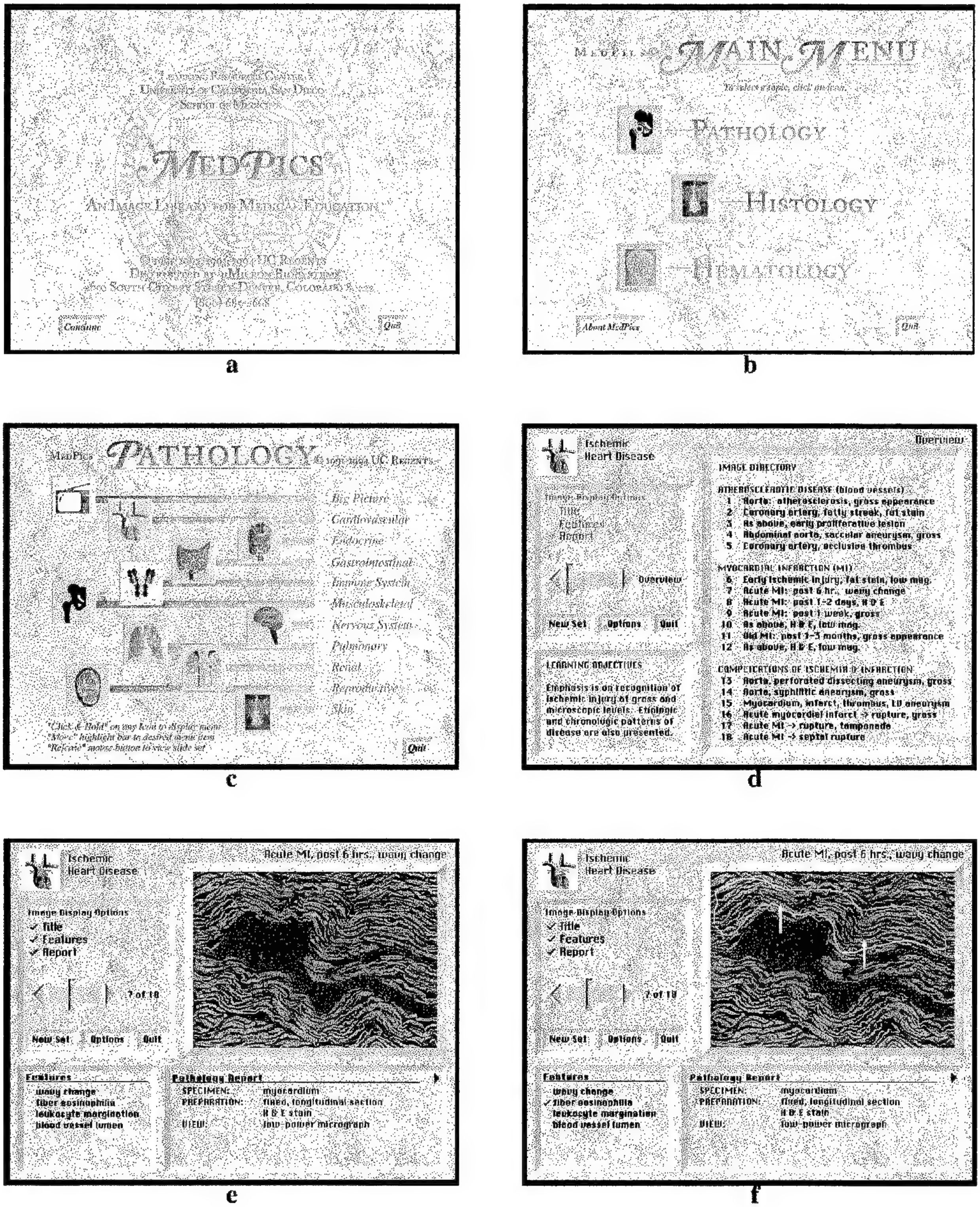


Fig. 1 - Major Frames from MedPics CD-ROM.

correlation, pathology pointers and lastly the credits. One special feature for students is the Quiz Mode, which displays the images without giving any other information until it is requested. This program has had a positive impact on the second year medical students and has also improved student attitudes toward computer-based resources and development.

Some schools have developed larger archives of digital images. The University of Utah has an archive of over 1800 images in their electronic laboratory WebPath, which are available both on a CD-ROM and via the World Wide Web. These images demonstrate gross and microscopic findings associated with human disease, and are used extensively in the medical student pathology course at the University. Diagrams, electron micrographs, and X-rays are also used, but to a much lesser extent than with MedPics. Each image is supported by a text field to assist in learning about normal and abnormal features for the particular disease displayed.

WebPath was produced by Dr. Edward Klatt two years ago to support his pathology courses for second year medical students. He explained that having the course materials on the Web avoided many labor intensive activities associated with maintaining sets of kodachromes and glass slides. He decided last spring to put the material on a CD-ROM for two reasons. First, the slowing down of the Internet became so bad that modem access for the images was frustrating. Second, foreign sites were encountering bandwidth problems when trying to access the images over the Internet. Both of these problems have been resolved with the availability of the CD-ROM.

Utah has six major resource categories that images may be viewed under: General Pathology (images by mechanisms of disease), Organ System Pathology, Laboratory Exercises, Mini-Tutorials, Clinical Pathology, and Histopathology. Recently, two more categories were added which are the Examination category that has over 1500 multiple choice questions and sample essay items for students to work with, and the WWW Medical Resource Sites, which contains several information resources that are related to the science of medicine (Figure 2-a).

Viewing an image is again as easy as one, two, three. By clicking on one of the image categories of the main menu you will be shown a more comprehensive list of that category (Figure 2-b). For example, if you click on Organ System Pathology, a list of all the available organ systems will come into view. From that list, you choose the specific section of images you would like to view, such as Dermatopathology Index, which will transfer you to an index of images for that section (Figure 2-c). This index also states whether the images are gross or microscopic. By clicking on the image of your choice, a full color, text supported image will appear on the screen within a matter of seconds (Figure 2-d). Finally, this screen gives you the option to move directly forward or backward to other images without returning to the index as well as to return to the index directly.

3.4 Government Databases

The Armed Forces Institute of Pathology (AFIP) serves to provide the military, Veterans Administration, and federal and civilian pathologists with consultations, education, and research services. The AFIP has recently taken advantage of the rapidly expanding Internet. They offer many new services, which are displayed on the opening page of the Web site (Figure 3-a). Some of the choices on their home page include a description of their mission, listings of educational programs and other services sponsored by AFIP and ARP (the American Registry of Pathology), an on-line edition of The AFIP Newsletter, information from the National Museum of Health and Medicine, a sampling of the AFIP Atlas of Tumor Pathology now available on CD-ROM, as well as an option to reply with feedback.

Since 1993, the AFIP has offered a useful service for those pathologists who are able to digitize images. Through this telepathology program, pathologists can transmit images using a file transfer protocol (ftp) to the AFIP and receive rapid, expert diagnostic opinions. A report is faxed

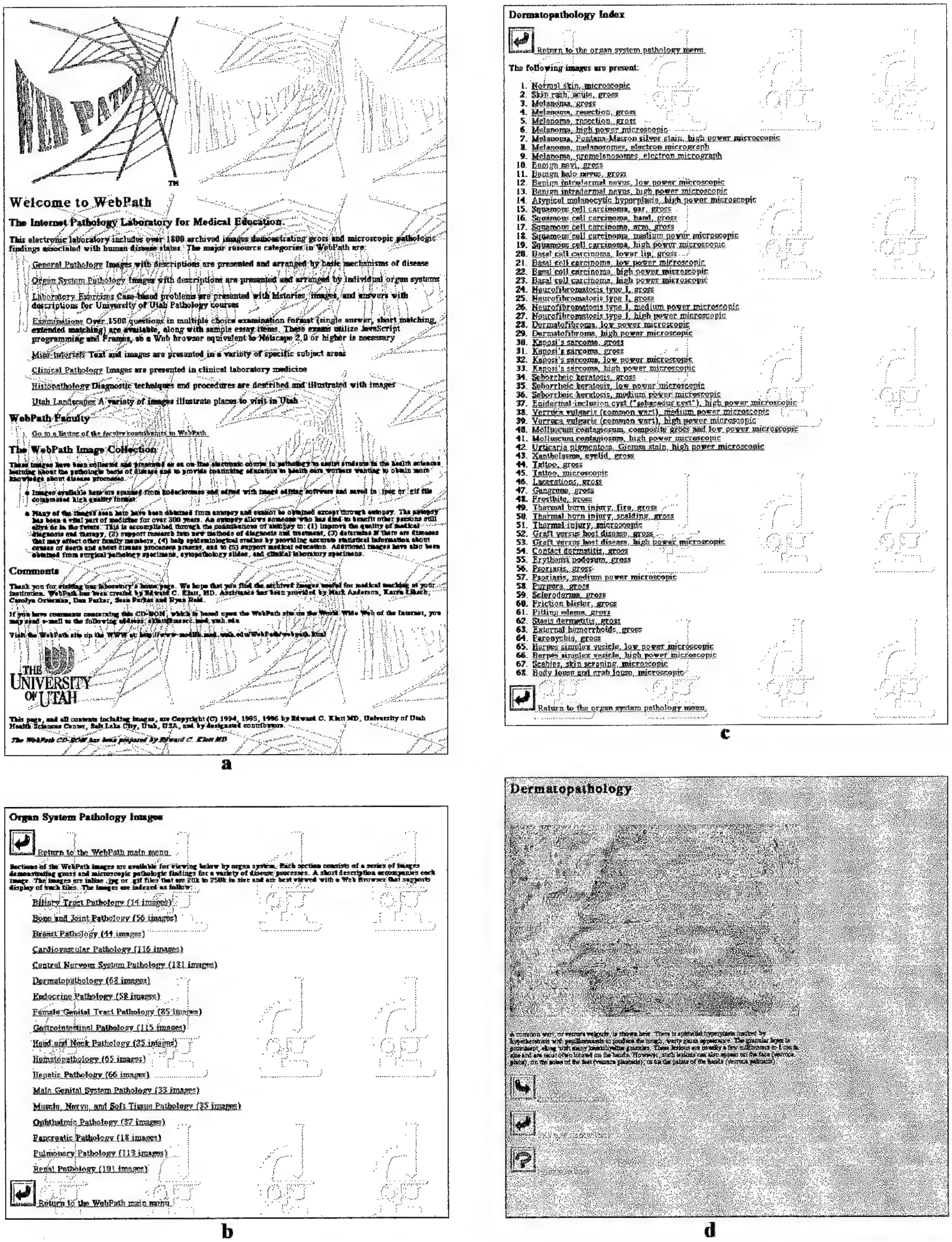


Fig. 2 - Major Frames from WebPath.

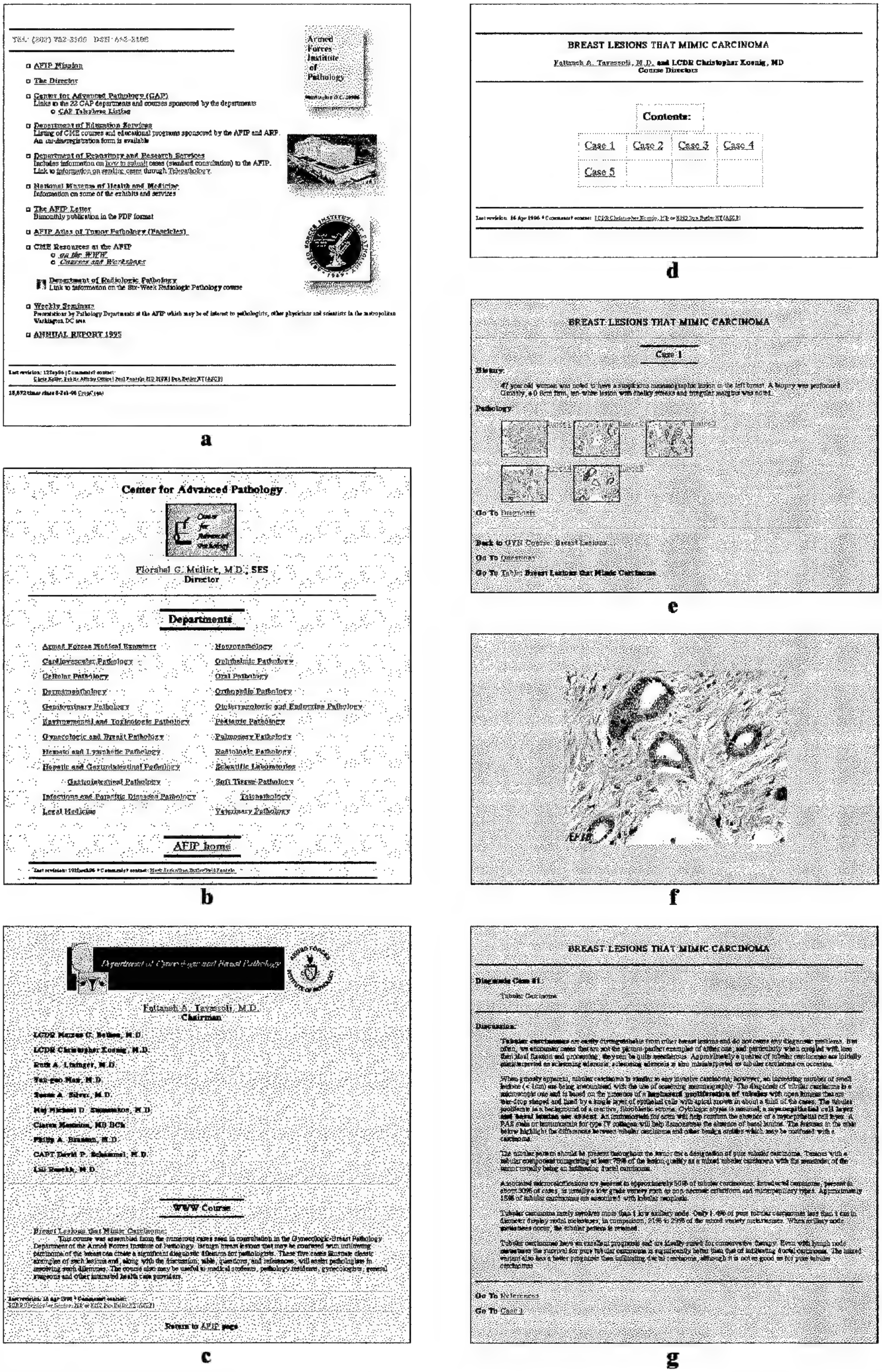


Fig. 3 - Major Frames from the AFIP Web Site.

to the pathologist within four hours. The number of cases processed using telemedicine is still small compared to the 50,000 cases received each year by the AFIP, but the number is increasing.

Another service now available on the World Wide Web are the virtual courses developed by The Center for Advanced Pathology (CAP), a division of the AFIP. Some of the 22 sub-specialty departments of CAP (Figure 3-b) offer courses which include case histories, gross and microscopic images, and discussions. The courses typically include a number of case studies (Figure 3-d) which were once seen in consultation with the AFIP. Each case is displayed on a page which shows "thumbnails" of each image (Figure 3-e). A thumbnail is a miniaturization of an image. Here they are displayed in a group to enable previewing of multiple images. The images can be enlarged for ease in viewing by simply clicking with the cursor directly on the thumbnail (Figure 3-f). The discussions can be found by clicking on the hypertext links to any discussion, history, pathological findings or diagnoses which are available with that case.

Another aspect of this web site that could be potentially very useful is the link to questions and evaluation forms for physicians interested in obtaining continuing medical education (CME) credits. The courses are worth only one unit, but they are easy to access at any time. There is no fee for military and federal government physicians, and only a small fee for civilian pathologists.

3.5 Commercial Databases

Chapman & Hall, a publishing company based in New York City now offers Pathology Atlases containing a collection of approximately 55,000 images available on CD-ROM. This exists as the largest source of digitized pathology slides available. Chapman & Hall advertises 21 image libraries on CD-ROMs, each representing a specific organ system. Eighteen image libraries are currently available for order today, including blood, lung cytology, skin/pigmented lesions, pituitary, and thyroid pathology, with three more modules (ovary, prostate, and benign lung pathology) in the works. It should be noted that neither the nervous system nor the muscular system are represented in the collection. Each atlas contains anywhere from 700 to over 16,000 images with supporting descriptive legends. In addition, lists of references and any applicable textual/lab data, including clinicopathological findings, immunology, cytogenetics, and chemistry are available. Lecture notes geared to residents and students are also included.

The CD-ROM opens with a main menu offering access to the information in six different ways: by disease atlas, feature atlas, references, feature definition, disease definition, or lecture (Figure 4-b). The user can choose the disease atlas to view images organized by disease (Figure 4-c). Clicking on a disease category of interest, the first color image appears on the screen with a brief description at the bottom (Figure 4-d). Clicking on the image will bring up a zoomed, full-screen image that is more than twice the original size (Figure 4-e). In order to view many images quickly, there is a button titled "thumbnails" which brings you to a screen with eight small images and their associated text (Figure 4-f). There are also direct links to a list of related references, an extended definition of the disease (Figure 4-g), and other pictures and cases.

With the feature atlas, images can be accessed by first electing certain descriptive terms in the main menu (Figure 4-h) and then choosing from more specific submenus that appear over this main page (Figure 4-i). This enables you to compare an unknown specimen to slides defined in the module. The objective is to make comparisons quick and easy.

Another useful tool available in the pathology atlases are the lecture series. After choosing a subject from the lecture menu, information is displayed at the resident or medical student level (Figure 4-k) with links to related images (Figure 4-l).

Mosby Multimedia, a publication company based in England, has produced a single CD-ROM which is modeled on the textbook *Pathology,* by Alan Stevens and James Lowe. This CD-

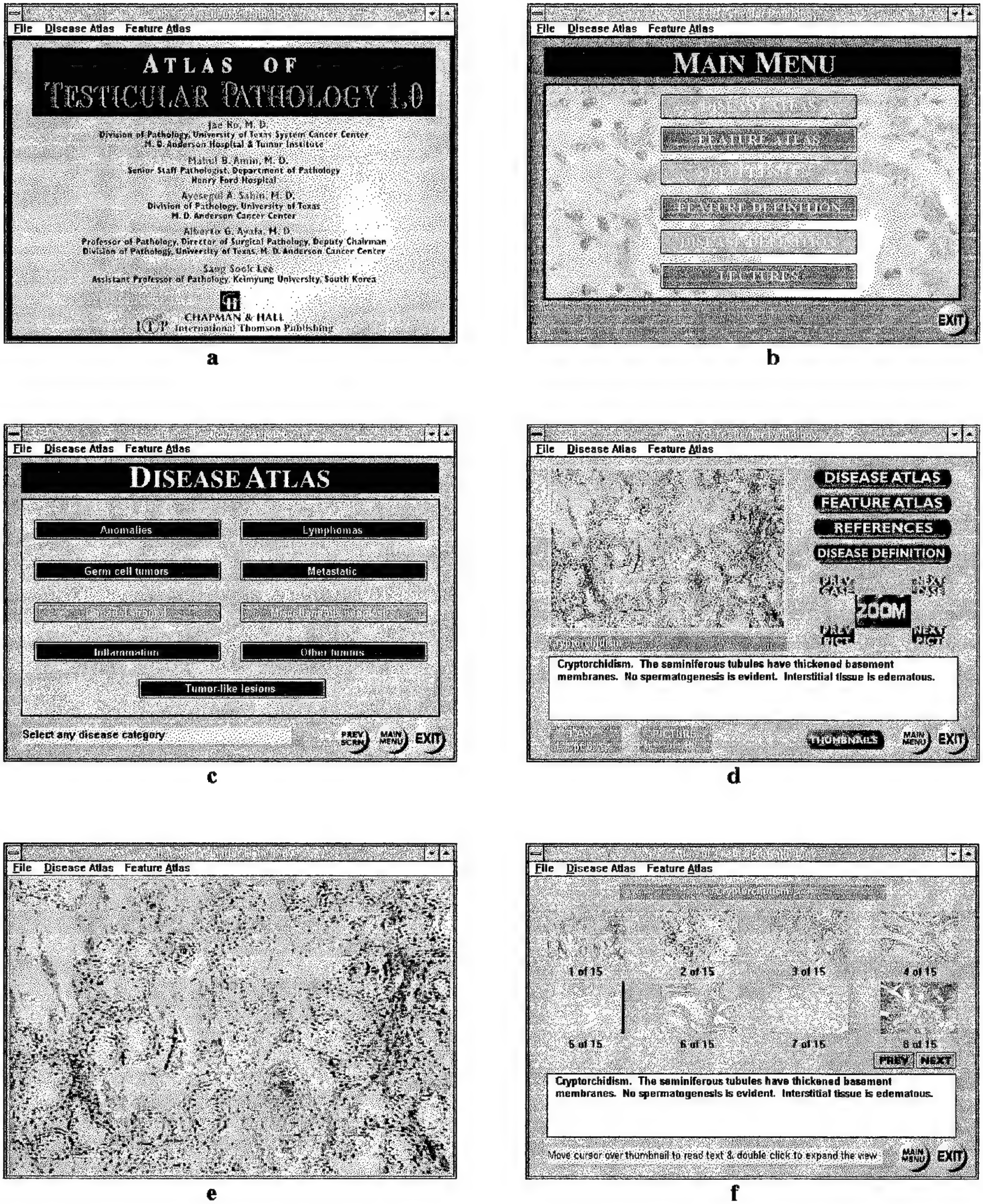


Fig. 4 - Major Frames from Pathology Atlas, Chapman & Hall.

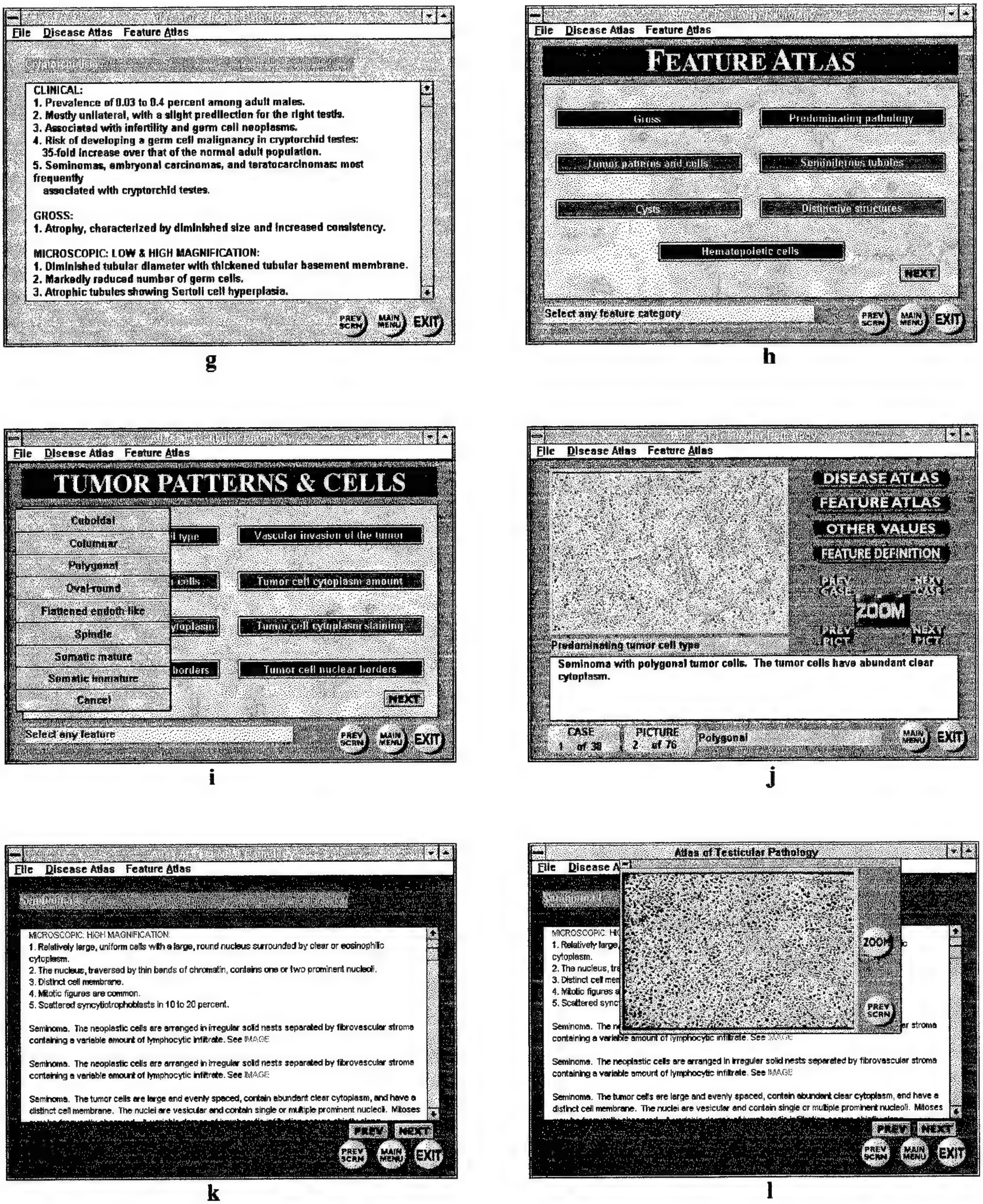


Fig. 4 - Major Frames from Pathology Atlas, Chapman & Hall.

ROM serves as an educational tool to help students learn more about basic pathological processes and clinical pathology. The user can turn the pages of this virtual book by clicking on "curled corners" of the page. Each page is accompanied by text as well as diagrams, charts, illustrations or photomicrographs. The zoom feature allows the user to view an image magnified (Figure 5-c). It works very much the same as an ordinary microscope: only a portion of the enlarged image can be seen at once and as you move the cursor up with the mouse you scan down the image. This orientation is inverse to that customary to that used in the U.S.A. It also applies to moving around the image from left to right, and right to left. This makes viewing an image at higher magnification very intuitive to those who are already accustomed to the standard light microscope.

Many colorful 2-D and 3-D animations are included throughout the "book." In certain cases sound files are added, such as with the three introductory movies that explain how to use the features of the program. *Pathology* is also set up to "speak" out the main text and figure descriptions throughout the CD-ROM, as long as you have the right extensions installed on your computer.

The search features allow you to quickly browse through chapters of interest, as well as locate more specific material from the extensive index. Figure 6-d shows one browsing tool called the "flickbook." The chapters are displayed by number, and the titles appear at the bottom as you move the cursor across each button. Clicking a button takes you directly to that chapter. There is a slider beneath the flickbook's main display window which you can move from side to side to quickly preview pages of that chapter. When you find a page of interest, releasing the mouse takes you directly to that page. You can place a bookmark on that page, allowing you to return to that page from anywhere in the book.

In order to locate pages by subject, you can use the search feature, shown in Figure 5-e. There is an alphabetical listing from which you can search, but you may also type a word or phrase into the box at the bottom of the display to view any related material. A small defect was detected in this search feature. Clicking on some items in the alphabetical listing links you to the wrong page. Mosby Multimedia has been informed of the defect, and are working to remove the bug. The newest version 1.1 was released after the same problem was encountered in version 1.0, but apparently the problem was not completely solved.

3.6 Kensal Database

The Kensal Corporation is currently developing an interactive CD-ROM "virtual microscope" to be used by medical school students and pathologists. The CD-ROM uses full-coverslip lensless scans and the accompanying high-magnification images to give the user the impression that he/she is observing a glass slide using Kensal's telepathology workstation. Approximately 264 images comprise the CD-ROM, of which 24 are full-coverslip guide images.

The user has two options with the virtual microscope. First, the user can explore the full-coverslip image at full resolution by moving about the coverslip. Second, he/she can select one of the regions of interest for higher magnification and explore it in a similar manner.

There are three ways the virtual microscope user can access images. The first method is by using the Model Search, in which a human model appears on the screen with several different organ systems to choose from (Figure 6-b). The user has the option to change from a male to a female, and to rotate the model from a front view to a rear view. Clicking on an organ system will bring up one guide image pertaining to that system (Figure 6-c). From that screen the viewer has the option to obtain the diagnosis/information about the tissue (in the form of text and voice annotations), or to view a full-screen image of the tissue (Figure 6-d). In addition, located on the guide image are markers indicating the regions of interest (ROI). The size of the markers indicate the degree of magnification. Larger markers are affiliated with low power magnifications, while

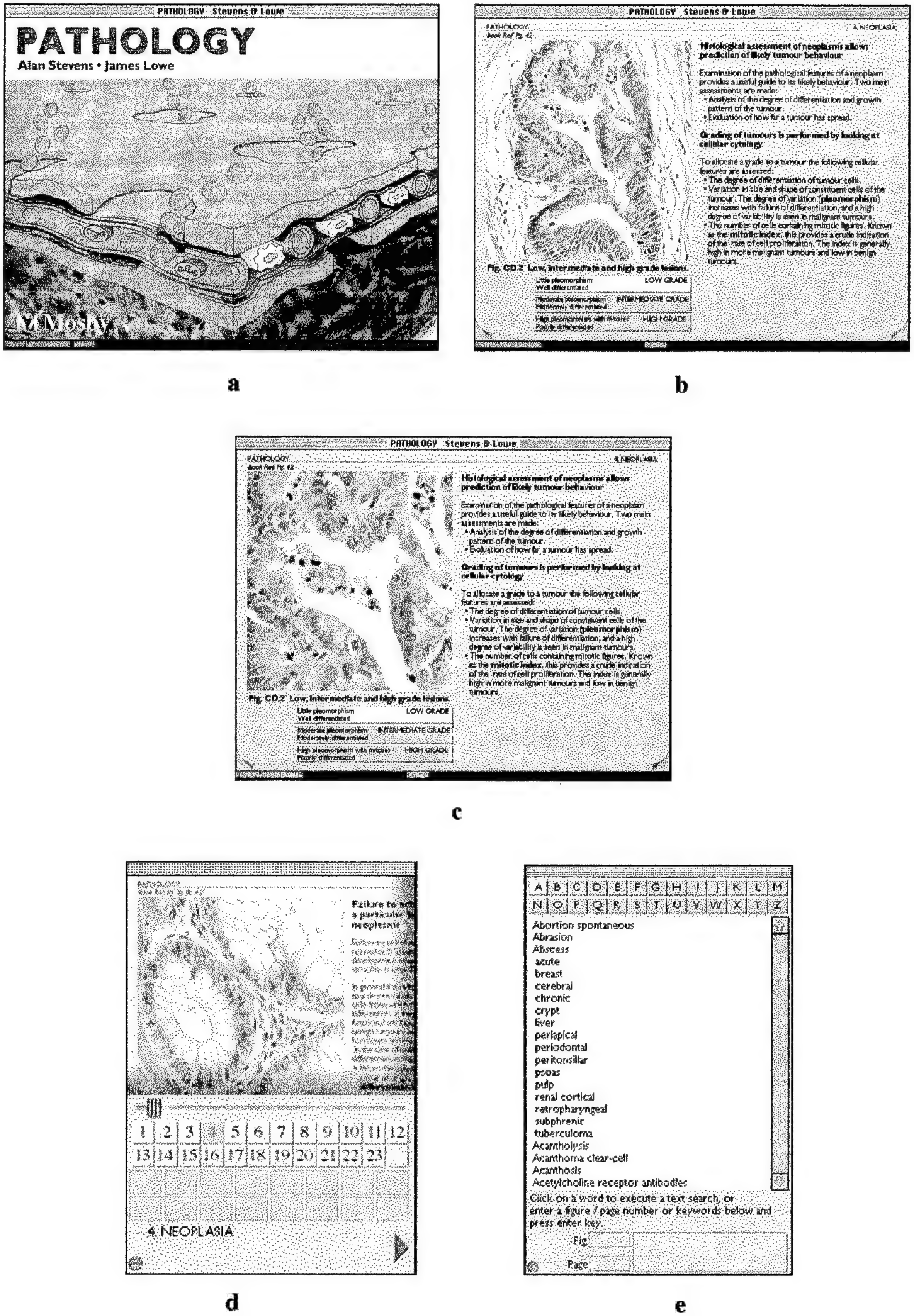


Fig. 5 - Major frames from Pathology CD-ROM.

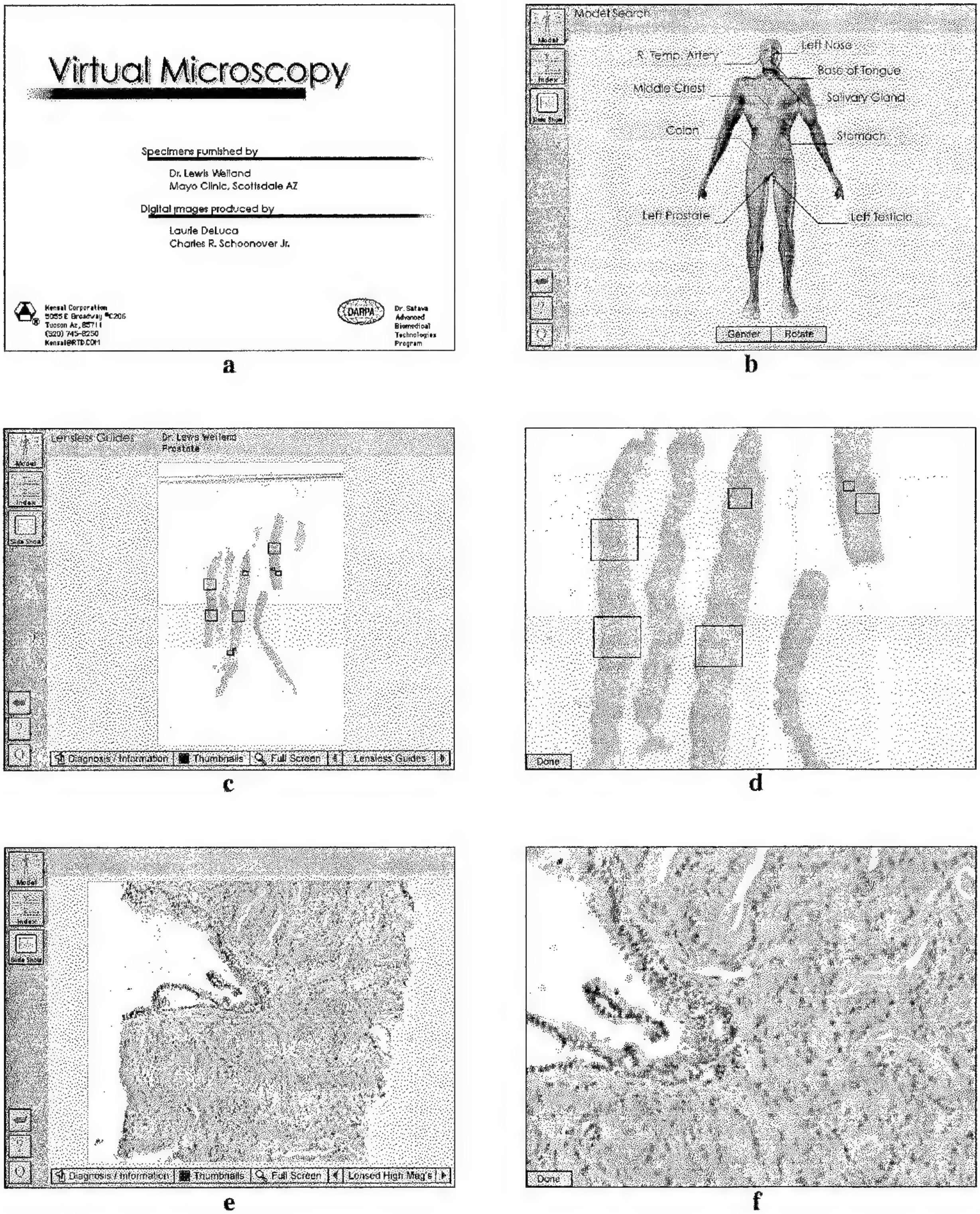


Fig. 6 - Major frames from Virtual Microscope CD-ROM produced for U.S. Army Medical Research Command.

small markers indicate higher magnifications of only a small area of tissue. By clicking on one of these markers, a high magnification image will appear for that location (Figure 6-e). Again, the diagnosis/information may be obtained for that image, as well as bringing the image to the full scale of the screen (Figure 6-f).

The second method of accessing images is through an index. In the index, all of the images are listed alphabetically by topology and by organ system, offering two ways to access the image of your choice. Clicking on the desired image will bring you to that specified guide image. The same process for accessing the high magnifications is followed as is done with the Model Search.

Lastly, the user can choose the "slide show" section, in which they may choose images from an index to be saved and played back automatically or saved to a disk. This section includes the high magnification images and any voice annotations that go along with the images.

3.7 Summary

Each image database reviewed differs in the total number of images available, as well as in how the images are distributed among organ systems. Kensal Corporation has taken a closer look at the microscopic image counts for each database to distinguish between which institutions are focused in certain areas and which are lacking in other systems all together. A series of pie charts representing the microscopic images has been developed for each organ system (Figure 7). This has been done so that the viewer may see how each image database compares with the other's representation of the systems of the human body.

After counting the number of microscopic images in each organ system category, percentages from each database were calculated and entered into the graphs. Therefore the largest slice of the pie represents the database which offers the greatest emphasis of microscopic images in that system when compared to the other databases. The viewer must take into consideration that these pie charts are only showing the "relative emphasis", and not the total number of microscopic images. For instance, Chapman & Hall has the greatest number of microscopic images in the female reproductive system, estimated at 1,326 images. The pie chart for this system, however, shows the AFIP with the largest section of the pie for that organ system. While the AFIP only has 126 images in the female reproductive system, this is a large percent of their 347 images (37%). Chapman & Hall's 1,326 images of that organ system represent only 3% of their total 55,000 images. Therefore, Figure 7 is a tool that can be used to figure out which databases emphasize certain systems. The viewer should remember that this chart in no way compares the total number of images available (this information can be found in Table 2).

Chapman & Hall clearly contains more images overall than any other database. Due to the high volume of slides though, it was difficult to determine the exact number of microscopic images available in the collection. Sanjiv Patel, an engineer and programmer for this collection, stated that no exact count of microscopic images was available from the publisher at this time. He did estimate, however, that between 80 and 90% of the slides are microscopic images, with the remaining images being gross specimens. No diagrams or x-rays are included in the collection. To verify this estimate we did a count in two of the modules, The Atlas of Testicular Pathology and The Atlas of Thyroid Pathology. We found that these two atlases contained 77% and 99% microscopic images, respectively.

WebPath contains the second largest collection of microscopic images, with just under one thousand. Out of these images, each organ system is represented reasonably well. The areas that contain the most images are the respiratory system and the cardiovascular system, while the areas with the least number of images are the male reproductive system and the muscular system.

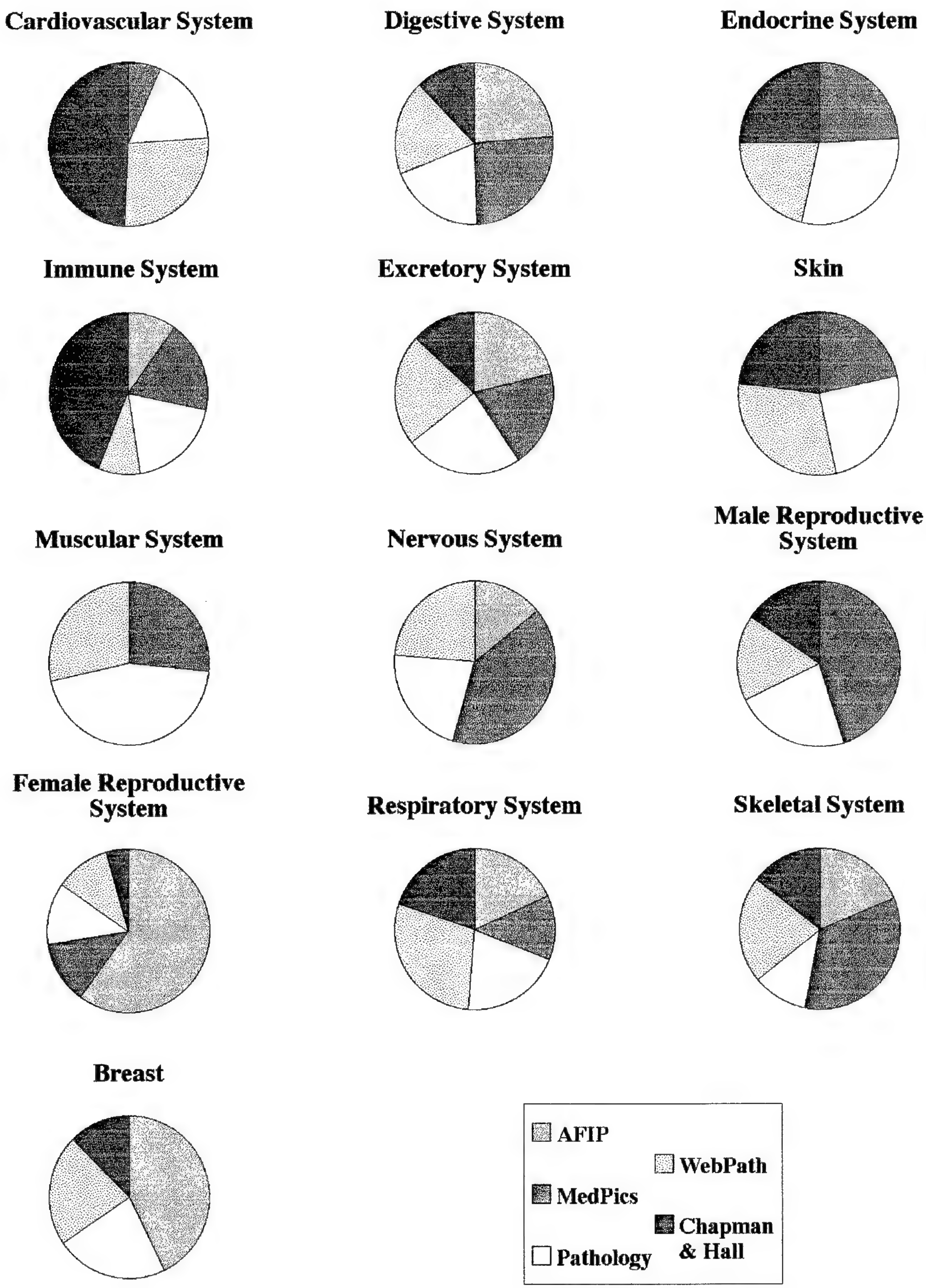


Fig. 7 - Relative Emphasis of Microscopic Images per Organ System.

TABLE 2 - Image Libraries

Features Surveyed			
Publisher	University of California, San Diego (LaJolla, CA)	University of Utah (Salt Lake City)	Armed Forces Institute of Pathology (Washington D.C.)
	Department of Pathology	Department of Pathology	Center for Advanced Pathology
Internet Address		http://www-medlib.med.utah.edu/WebPath/webpath.html	http://www.afip.mil
Name of Product	MedPics	WebPath	Armed Forces Institute of Pathology Web Site
Number of Disks	1 disk	1 disk	NA
Price	$79	$50.00	Free
Available	Yes	Yes	On the Internet only
Demo Disk	No	No	No
Operating System	Windows 3.1 or Macintosh System 7.0	Macintosh or PC compatible	Macintosh or PC Compatible
Minimum System Requirements			
RAM	5MB		
Processor	386SX 33MHz		
Hardware Requirements	Double-speed CD-ROM drive, mouse	Mouse or compatible positioning device	Mouse
Monitor Requirements	8-bit color (640 x 480)	800 X 600 resolution	
Software Requirements	None	Web browser	Web browser
Total Images	580	2007	347
No. Gross Images	172	895	2
No. Microscopic Images	350	997	338
No. Diagrams and Illustrations	31	56	0
No. Electron Micrographs	24	57	0
No. X-Rays	3	2	7
No. Images per Organ System			
Cardiovascular System	11	125	0
Digestive System	72	150	63
Endocrine System	21	53	0
Immune System	43	58	23
Excretory System	34	112	35
Skin	16	66	0
Muscular System	9	28	0
Nervous System	47	78	16
Reproductive System, male	17	18	0
Reproductive System, female	27	66	126
Respiratory System	23	146	31
Skeletal System	30	54	16
Breast	0	43	28
Textual Data	Supporting text fields on specimen, preparation, view, key features, and diagnosis. Provides a list of learning objectives, and a directory of images for each tissue/organ system.	Supporting text fields on specimens.	Images have hypertext links to case histories and diagnoses.
Color	Yes	Yes	Yes
Voice	No	No	No
Zooming Capabilities	No	No	No
Technical Support	No	No	No
Indexing Method	Images categorized by organ system.	Images categorized by general pathology, organ system pathology, laboratory exercises, examinations, mini-tutorials, clinical pathology and histopathology.	Images categorized by departments of the Center for Advanced Pathology.
Coding/Standardization	No	No	No
Years on the Market	5	3	
Future Developments	Version 2.0 coming fall, 1996	Regular updates to Web site	Regular updates to Web site
Target Audience	Medical students	Medical students	General public, pathologists
Digitization (direct/35mm slide)		Images scanned from kodachromes.	
Additional Features which Distinguish it from the Competition	Program offers two modes: the standard teaching mode, or a self-testing mode to let users identify randomly presented images without on-screen descriptive cues. List of features which hide/display a graphic overlay on the image identifying the structure.	Description with illustrations of diagnostic techniques and procedures. Multiple choice examinations and sample essay questions for self-testing. Available on CD-ROM and via the World Wide Web. Web site links to other medical education resources.	Some images are presented as courses, which can be viewed to obtain Continued Medical Education units of credit. Offers additional listings of CME courses and educational programs, and includes on-line regiatration forms.

TABLE 2 - Image Libraries (continued)

Features Surveyed			
Publisher	Chapman and Hall Publishing (New York City)	Mosby Multimedia (Eden Prairie, MN)	Kensal Corporation (Tucson, AZ)
Internet Address	http://www.chaphall.com/chaphall.html		http://www.amug.org/~kensal
Name of Product	Pathology Atlases on CD-ROM (1.0)	Pathology	Virtual Microscopy
Number of Disks	18 disks		1 disk
Price	$2,750	$59.95	
Available	Yes	Yes	Coming soon...
Demo Disk	Yes	30 day preview	Yes
Operating System	Windows 3.1 or higher	Windows 3.1 or Macintosh System 7.0	Macintosh
Minimum System Requirements			
RAM	8MB	8MB	8MB
Processor	486SX processor	68030 Processor or better	
Hardware Requirements	50 MHz double-speed CD-ROM drive, mouse	Double speed CD-ROM drive	
Monitor Requirements	16-bit color (640x480)	16-bit color (640x480)	8-bit color (640 x 480)
Software Requirements	None	None	None
Total Images	55,038	799	about 300
No. Gross Images	8253	343	
No. Microscopic Images	46785	316	
No. Diagrams and Illustrations	0	122	
No. Electron Micrographs	0	7	
No. X-Rays	0	11	
No. Images per Organ System			
Cardiovascular System	10593	25	
Digestive System	4556	48	
Endocrine System	2890	23	
Immune System	13813	41	
Excretory System	3110	37	
Skin	2342	17	
Muscular System	0	14	
Nervous System	0	23	
Reproductive System, male	778	8	
Reproductive System, female	1326	24	
Respiratory System	4689	33	
Skeletal System	1696	9	
Breast	1101	14	
Textual Data	Supporting text fields on specimens, extended descriptions of clinical and pathological findings and diagnoses, and lists of references.	An interactive text book, including both a brief and an expanded version of the text. Underlined sections of text are linked to cross-references.	
Color	Yes	Yes	Yes
Voice	No	Yes	Yes
Zooming Capabilities	Full screen option	Yes	Full screen option
Technical Support	Hot line number, instruction booklet	Mosby Multimedia Tecnical Support Hotline	Instuction booklet
Indexing Method	Images categorized by specific disease, or feature.	The CD-ROM is organized like the original text book, indexed by chapter title as well as by feature. The search screen allows you to select items by word, phrase, or page number	Images listed by organ system.
Coding/Standardization	No	No	SNOMED coding
Years on the Market			NA
Future Developments	Three new modules expected in the next year.		
Target Audience	Pathologists	Medical Students	
Digitization (direct/35mm slide)			Direct digitization/scanning
Additional Features which Distinguish it from the Competition	Lecture notes with hypertext links to images are avilable.	Includes introductory videos that explain how to use the program. Colorful 2-D and 3-D animations. Images can be magnified further for viewing. Most photographs, diagrams and animations are accompanied by buttons to display labels and areas of interest.	"Virtual microscope" allows you to first view an entire slide, from which you can choose regions of interest for higher magnification.

Mosby Multimedia's *Pathology* CD-ROM also represents each of the thirteen organ systems. The largest percentage of their images lies within the digestive system, and the least within the male reproductive system. Likewise, MedPics does a good job of representing all but the breast in their CD-ROM.

The AFIP, on the other hand, leaves five systems unrepresented with no images: the cardiovascular system, the endocrine system, skin, the muscular system, and the male reproductive system. The female reproductive system alone is represented by over a third of their images.

3.8 Acknowledgments

The previous table (Table 2) lists detailed data of these six databases. The information was collected by Kensal Corporation through contacting vendors and creators, then reviewing the contents of each program. We do advise that readers interested in purchasing any of the CD-ROM's verify the price quotes, availability, and current status of the product.

We would like to acknowledge the creators, engineers, and publishers of the databases for their help in this review. Financial support is being provided by DARPA via the U.S. Army Medical Research and Materiel Command.

4. HOSPITAL INFORMATION SYSTEMS

Information systems (IS) are defined as a set of people, procedures, and resources that collect, transform, and disseminate information in an organization. The goal of IS is the production of accurate and timely information - products for end users. An IS should also produce feedback about its input, processing, output, and storage activities to determine if established performance standards are being met.

The Hospital Information System (HIS):

- ♦ manages hospital finances and resources
- ♦ furnishes decision support through ad-hoc reporting
- ♦ automates office work at all levels
- ♦ tracks/manages patient data, care and billing
- ♦ establishes inter-communication and data-exchange between: other hospitals, insurance and billing agencies, clinics, laboratories, nursing stations, other information systems and data repositories, wired or wireless instrumentation and printers, technologists, and physicians in the hospital or elsewhere.

The primary motivation behind HIS implementation is cost savings. An inherent secondary benefit is improved health care and lower error rates due to improved organization and communication.

4.1 HIS Modularization

Since more feature-sets and end-users have been added to the HIS domain over the years, the HIS has become increasingly modular with outgrowths in both clinical and laboratory information systems (CIS/LIS). Savings through better organization, increased automation, and faster order/result turnaround are the compelling reasons for outgrowth and modularization. Each sub-IS module not only acts as a store-and-forward/fault-tolerant repository of data within the

central HIS. This eliminates communication traffic problems between nodes. Data being transmitted is first stored and waits until bandwidth is available for transmission. This does two things, 1) frees up the end-user's terminal to work on other things while the data is queued and, 2) ensures fault-tolerant delivery of data in case of temporary disconnection during transmission--data can be resent. Each module also provides domain-centric ad-hoc feedback to inquiring administrators who must report to hospital enterprise leaders and government regulating agencies. The six related and overlapping systems within the health care field are:

- Management Information Systems
- Financial Information Systems
- Telemedicine Information Systems
- Knowledge Systems
- Public Health Information Systems
- Research Systems

4.2 HIS Security

Throughout the chain of hospital rank and command, layered need-to-know based security protects sensitive information within the HIS. While nursing stations can prepare work lists based on patient needs, they cannot view executive level reports. While the admissions-desk can see bed availability in real time, they cannot change laboratory results. While physicians can submit pharmaceutical and laboratory orders, they cannot admit, discharge, or transfer (ADT) patients. Security is necessary to protect patient privacy, control efficiency and order, as well as, prevent accidents, fraud, or deliberate reprisals and sabotage against the hospital enterprise.

4.3 A Powerful Management Tool for Strategic Planning

Since hospitals are in a market driven by cost containment, enterprise leaders are constantly looking for ways to minimize the cost of care in all service areas. The HIS, when well implemented, can be used as a powerful management tool to guide decision- making. The ideal HIS provides rich insight and decision support for the optimal financial structuring of the hospital.

"Managed care" was cited as the most significant force driving increased computerization in health care.

Managed care continues to represent a cost-centered approach to computing, as 49 % of more than 1200 surveyed in the 1996 HIMSS/HP Leadership Survey said accessing and analyzing financial information for better management of overall costs is the most important advantage of computer technology for managed care.

However, clinical concerns [of managed care providers] are becoming more prominent, as 45% of those surveyed said accessing clinical information (data and images) from specialty services was most important. (For more information, see Appendix A, 1996 HIMSS/HP Leadership Survey.)

4.4 Cost-Containment Pressures Drive HIS Innovation and Integration

In the near future, HIS will likely be linked to a Community Health Information Network (CHIN) to help minimize costs within a group of collaborating health-care providers. In addition, research by the National Information Infrastructure-Health Information Network (NII-HIN) Consortium is underway to develop standards to provide transparent linkages between CHINs

through a national information infrastructure. Finally, there is some movement towards a Global Health Network (GHNet) which is focused on the critical role of prevention in reducing health care costs through rapid, accurate transmission of information. Other innovations include computer-based order/results entry and point-of-care reporting.

4.4.1 Community Health Information Networks

"CHINs are community-wide electronic networks of health care providers, medical facilities, payers, pharmacies, and other health care support companies that allow the sharing of patient medical and financial data in a more efficient manner. CHINs can also support the sharing of radiological images and live telemedicine. A regional CHIN promises to improve the quality of patient care and lower the cost of health care in the community." Before a hospital can be integrated into a CHIN however, it must support a Computer-based Patient Record (CPR) that can be transparently passed to other hospital HISs of likely dissimilar implementation. Many hospitals still keep much of the patient record on paper in a folder labeled with the patient's unique HIS index number. Recently, enormous industry and media attention have been focused on the CPR. Despite this, hospitals in general are hesitating to implement a CPR. CHINs are thus just emerging in the health care industry but will play a significant role in the near future of health care.

4.4.2 Computer-based Patient Record (CPR)

The CPR concept is fundamentally a computer-stored collection of health information about one person linked by a personal identifier. The CPR or the "electronic patient record" are terms used by vendors interchangeably but refer to different levels of computerization. Clarification regarding these levels has been outlined by the Medical Records Institute (MRI), founded on the principle that the future of health information technology lies in the successful creation and implementation of electronic health record systems. Although in fact five levels have been defined, only the first two levels have been achieved--levels 3 through 5 are not felt to be possible for some time. The five distinct levels of computerization for patient information systems has been outlined by MRI as follows:

Level 1: Automated Medical Records

Are paper-based medical records with as much as 50% of the printed content computer generated. Level 1 automation within the hospital environment is focused around the following functions:

- ADT (Admission/Discharge/Transfer) systems
- Improved capture of patient information through digital dictation systems
- Patient accounting and its linkage to clinical information
- Departmental systems (i.e., Radiology Information Systems, Laboratory
- Information Systems, Pharmacy Information Systems, etc.)
- Order Entry/Results reporting (discussed in section 4.4.3, below)

Other innovations parallel to the paper-based medical record are nursing/bedside computing (discussed in section 4.4.4), implementation of an enterprise-wide master patient index, the linkage of various parts into an enterprise-wide network, the development of interface engines and imaging.

Level 2: Computerized Medical Record System

Level 1 automation does not solve the space shortage in record storage, nor create an electronically available record. A level 2 computerized-medical record system (or document imaging system) allows paper-based medical records to be created, then scanned, and indexed within a computer system with the same automation functions as level 1. Optical Character Recognition (OCR) or Intelligent Character Recognition (ICR) do not fit into level 2 automation since the scanned documents are stored on optical disks as unchangeable images, not ASCII-based data-sets. Level 2 is the only method in existence as of this writing to computerize the medical record in a paperless system.

Level 3: The Electronic Medical Record

The level 2 computerized medical record has basically the same structure as the level 1 paper-based medical record. The level 3 electronic medical record has the same scope of information in level 2 but the information is rearranged for computer use. While the level 1 paper-based records system is a passive storage device, level 3 can provide interactive aiding of the decision-making process by knowledge coupling, providing decision support, and many other functions. Level 3 requires a secure enterprise-wide infrastructure for appropriate capture, process and storage of patient information.

Level 4: Electronic Patient Record Systems (also called Computer-based Patient Record Systems)

The patient record has a wider scope of information than the medical record. It combines several enterprise-based electronic medical records concerning one patient and assembles a record that goes beyond the enterprise-based retention period.

Level 5: The Electronic Health Record

The more comprehensive collection of an individual's health information is the level 5 electronic health record. It differs from the electronic patient record in the unlimited amount of health information captured by caregivers regarding a person. It includes wellness information possibly captured by the individual or parents, therapists, etc., including data for example on behavioral activities such as smoking, exercising, dietary and drinking habits. The electronic health record is maintained through cooperation between the individual who controls his or her health information, and the caregiver.

4.4.3 Computer-based Order and Results Entry

Savings from an order entry module in the HIS include form costs, lost charges, a significant reduction in "telephone tag" between nursing and ancillary departments, elimination of mistakes due to legibility, and the establishment of controls for accountability within the hospital. A results reporting module allows entry of both brief and verbose "status" reports on received orders.

4.4.4 Computer-based Point of Care

A recent HIS appendage and innovation for cost-savings are computerized point-of-care systems (CPSI). HIS vendor CPSI markets a "Chart Cart" --a portable PC on a medicine-cabinet cart with a touch sensitive screen and bar code reader, all wirelessly connected to the HIS--which allows Nursing Services personnel to enter information into the HIS at the patient's bedside. Clerical functions are automated and duplicate entry of information into nursing documents is

eliminated. Charges for administered medication can be billed immediately by using the keyboard and bar code reader to scan the medication container.

HIS vendor MEDITECH also has a 14-ounce, hand-held personal digital assistant (PDA) for computer-based point of care. End users of this device are nurses, nurses aides, and therapists. The PDA holds data for 10-20 patients and keeps track of the "whereabouts of physicians". When a nurse's shift begins, the nurse downloads patient records into the PDA and then administers to the need of the patients. During the shift, the nurse can operate the PDA with one hand's thumb--to see orders and record results--while administering care with the other hand. After the shift, the data in the PDA is uploaded into the HIS.

4.5 Health Care Information System Priorities

The most important IS priorities for health care organizations are upgrading their IT (Information Technology) infrastructure and integrating systems in a multivendor environment. Reengineering to a patient-centered computing environment is also receiving priority attention from health care organizations. And organizations are following through by completing these projects.

4.6 Computer Imaging In HIS

Computer imaging is relatively new to the HIS. Several outgrowths are currently integrating images and text in stand-alone modules (i.e., radiology, paperless-office, and telemedicine modules). However, there is no standard way to integrate the text-based medical record and related digital image-based entities together for call-up throughout the HIS, much less across hospitals or CHINs. Thus, a tremendous amount of work yet lies ahead to create, what might be coined as, the "Graphical Patient Record" (GPR).

While standards do not exist yet meshing text and large binary objects like images for HIS-wide access, Los Alamos National Laboratories (LANL) has recently announced TeleMed which contains an experimental GPR focused currently in teleradiology. TeleMed, based on a distributed national radiographic and patient record repository which could be located anywhere in the country, is designed to assist doctors in treatment planning through viewing patient treatment histories and associated radiographic data. These data can be viewed simultaneously by users at two or more distant locations for consultation with specialists in different fields. LANL claims that TeleMed "is the first to provide transparent access to patient record components over a Wide Area Network (WAN), building the complete patient record from various partial records and displaying that in an integrated manner to the healthcare provider."

Industry standards are needed for seamless integration of images throughout the HIS. Once again, no standard exists which integrates text and images across the entire HIS as of this writing; however there are several SDO's (Standards Developing Organizations)--who have good foundations and the technical resources--developing such a standard. These groups and their progress will be described below under section 4.9, Medical Informatics Standards Groups.

4.7 Reports Available on HIS

Available HIS reports are endless and their titles vary from vendor to vendor. Often, vendors will tailor report content and structure to the needs of the hospital. Thus, unlike the IRS or other government branch, there is little report standardization, except in the insurance billing modules and in the reports destined for accreditation overseers.

Often provided in the various HIS modules, is the ability to generate ad-hoc reports; thus, in addition to the "canned" reports unique to a particular HIS vendor, reports of any content or structure can be generated through Standard Query Language (SQL) inquiries on a database.

However, the HIS end-user must learn how to use the SQL interface and the semantics of the query language before useful reports can be generated.

As mentioned in section 4.4.2 earlier, an extreme interest in moving to a paperless reporting mechanism has been manifest in many hospital enterprises, due to cost savings. Most of the HIS vendors are just now beginning to offer the "Level 2" document imaging ability. "Level 3" is highly desired, but requires physical and logical integration across disparate facilities and computer systems, with nearly a unique solution for each integration case. To understand the barriers to enterprise-wide electronic report exchange, the physical and logical architecture of the HIS will be discussed in the next section.

4.8 HIS Related Topics

Below the HIS application's layer is a complex data storage and exchange network. These networks are based on numerous standards necessary to bring order to the physical mediums used for communication, the inter-node communication protocols, the physical/logical interface to the computing platforms, the applications level communication management, and the monitoring and reporting instrumentation. The interconnected machines themselves make up a heterogeneous and distributed computing environment. Careful understanding of the standards at all levels are thus needed before attempting to add bilateral information exchange nodes to an existing HIS, lest the delicate system-balance of the HIS be upset.

There are many standards groups who's specifications are being used to implement the HIS. At the messaging level--the level where HIS nodes exchange information related to the health-care industry--various standards groups, many driven by HIS vendor innovation, have been working together to build the expanding field of medical informatics. At the lower hardware level, Institute of Electrical and Electronic Engineers (IEEE), International Standards Organization (ISO), International Telecommunications Union - Telecommunications (ITU-T), American National Standards Institute (ANSI), et al, have published networking specifications in circulation for years, used in HIS implementation. Newer negotiated-multiband technologies such as Asynchronous Transfer Mode (ATM) for information interoperability are also being used in some HIS implementations.

4.8.1 Medical Informatics

Biomedical Informatics is an emerging discipline that has been defined as the study, invention, and implementation of structures and algorithms to improve communication, understanding and management of medical information. The end objective of biomedical informatics is the coalescing of data, knowledge, and the tools necessary to apply that data and knowledge in the decision-making process, at the time and place that a decision needs to be made. The focus on the structures and algorithms necessary to manipulate the information separates Biomedical Informatics from other medical disciplines where information content is the focus.

4.8.1.1 sci.med.informatics Newsgroup

The medical informatics USENET newsgroup (accessed at the above address) is open to the Internet public. As stated in their Charter: The focus of this newsgroup will be the discussion of the grand challenges facing medical informatics today (and tomorrow). Appropriate topics include, but are not limited to:

* Medical Information Standards
* Medical Informatics Training
* IAIMS (Integrated Academic Information Management Systems)
* **Computerized Medical Records**

* **Clinical Information Systems** (including radiology, laboratory, pharmacy, nursing, etc.)
* **Physician Order Entry Systems**
* Computer-Aided Instruction
* Medical Expert Systems
* Nursing Informatics
* Announcements of Interest, e.g. **conferences, journals, societies**
* National Library of Medicine
* Health Information Networks
* **Medical Software Reviews**
* Research Funding Opportunities
* Policy Making (including procurement and certification of medical software)
* **Medical Software Engineering**
* Cultural/Sociologic Changes
* **Medical Software Security**
* **Telemedicine**
* Veterinary Informatics

4.9 Medical Informatics Standards Group

The term "standards" includes standards developed by accredited standards organizations and other categories of organizations who are affecting, or working on, technical, procedural, and systems standards, guidelines, professional protocols, minimum requirements, as well as industry practices necessary to enable the computer-based record system of the future to function. From this perspective, there are seven categories of organizations involved in the process:

1. Major standards organizations who develop application standards for health care
2. Professional societies involved in standards creation
3. Trade associations
4. Government organizations
5. Industry consortia
6. National players
7. Standards organizations for base standards

The Medical Records Institute provides an *International Directory of Organizations: Standards and Developments in the Creation of Electronic Health Records* which lists over 160 different groups working on standards in health care throughout the world; outlining their current projects, publications and reports.

One of the largest components in the HIS standards work in progress is the design effort taking place to specify how digital messages should be exchanged between HIS computer systems and what they should contain. These messages encapsulate information ranging from ADT updates to lab-results data. The messaging structures implemented in HIS systems today are analogous to the different foreign languages and/or dialects spoken in various regions of the earth--from the global HIS market perspective, every vendor has its own unique standard or, more frequently, *interpretation* of a local recognized standard (i.e., HL7, discussed later). Since a substantial technical investment is required to enable one vendor--faced with appending modules on to HIS systems from other vendors--to speak all these languages and dialects, convergence to a common language--or messaging standard--is the drive behind the messaging Standards Developing Organizations (SDOs) today.

4.9.1 The Message Standards Developers Subcommittee (MSDS)

In 1991 there were at least six organizations developing health care messaging standards, of which three were accredited by the ANSI. During that year, the European standards agencies

asked ANSI to clarify with whom they could coordinate health informatics standards. As a result, ANSI formed the Health Informatics Standards Planning Panel (HISPP) to coordinate the development of health informatics standards. HISPP's membership includes system vendors, professional organizations, SDOs, and various users of standards.

In turn, HISPP formed a subcommittee of its members who were standards developing organizations. This is the Message Standards Developers Subcommittee (MSDS). The members of MSDS are SDOs developing health care message interchange standards. The objective of the MSDS is to achieve harmonization of the standards that SDOs develop.

4.9.1.1 MSDS Member Organizations

ASTM:	American Society for Testing and Materials
DICOM:	Working groups of American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA)
HL7:	Health Level Seven
IEEE:	Institute of Electrical and Electronics Engineers Medical Data Interchange Working Group
NCPDP:	National Council of Prescription Drug Pharmacies
X12N:	Insurance Subcommittee of ASC X12

The MSDS formed the Joint Working Group for a Common Data Model (**JWG-CDM**) as an open standards effort to support the development of a common data model that can be shared by developers of health care informatics standards. The IEEE Committee has secretariat responsibility for the activities of the JWG-CDM. Thus, for all practical purposes, the IEEE Medical Data Interchange Working Group and the Joint Working Group for a Common Data Model are identical. The acronym JWG-CDM refers to these groups.

On June 6, 1994 the IEEE Standards Department made available the initial draft of the JWG-CDM standard as four postscript documents.

Duke University, North Carolina, maintains a repository for MSDS electronic files at:

(WWW) http://dumccss.mc.duke.edu/ftp/standards.html
(FTP) dumccss.mc.duke.edu

In addition, DICOM maintains electronic information at:

(FTP) xray.hmc.psu.edu

4.9.2 Health Level Seven (HL7) - Background

HL7 was founded in 1987 to develop standards for the electronic interchange of clinical, financial and administrative information among independent health care oriented computer systems; e.g., hospital information systems, clinical laboratory systems, enterprise systems and pharmacy systems. Currently, HL7 does not support images but is working with the ACR to merge the DICOM standard with HL7 for image support.

In the last three years, its membership has tripled to over 1,400 hospital, professional society, health care industry, and individual members including almost all of the major health care systems consultants and vendors. The HL7 standard is supported by most system vendors and used in the majority of large U.S. hospitals today. It is also used in Australia, Austria, Germany, Holland, Israel, Japan, New Zealand and the United Kingdom.

HL7 minutes, standard drafts, and sample source-code are available through Internet FTP servers on [dumccss.mc.duke.edu], WWW URL:

http://dumccss.mc.duke.edu/ftp/standards.html

Also supported is a discussion group on the HL7@Virginia.EDU list server.

Virtually all HIS vendors are HL7-compliant and most of the world, including the military, is merging their HIS systems and sub modules into this standard. However, each vendor's implementation of HL7 is somewhat different--a unique interpretation. Thus, while HL7 provides a strong measure of order to the messaging dilemma between HIS systems and sub-modules, it doesn't eradicate all communication problems. Interfacing two HL7-compliant systems, for example, requires much work on a technical level.

4.10 Data Interface Engines

Because of the complexity involved in interfacing modules to HIS systems, each with its own interpretation of a recognized messaging standard, many system integrators are turning to "data interface engines" to simplify the process.

Interface engines (IEs) are a complex middleware technology also known as integration engines, interface hubs, and application interface gateways. Typically, an IE is a separate computer which acts to translate and map data between other computer systems and their applications. These disparate applications must have the ability to exchange messages, for example through a messaging Application Programming Interface (API).

In the hospital environment, such IEs are used between HIS modules (i.e., the ADT module and the Radiology Module) perhaps purchased through different vendors with different hardware/software implementations. The benefits of using an IE include, 1) simplified HIS interface development since the IE is a tool-set designed specifically for that purpose, 2) centralized interface management capabilities (i.e., starting, stopping, monitoring, trouble-shooting), 3) superiority over point-to-point (PTP) interfaces since complexity is reduced through use of the centralized IE hub (i.e., if 5 different systems requiring bilateral interfaces need to interoperate with each other, 20 PTPs are needed, while only 10 interfaces are needed to an IE-based implementation--adding another node to the former requires 10 more PTPs while the later only 2 interfaces), 4) possible reduced costs for IE-based interface implementation when compared to paying application vendors for installing a PTP-based interface, 5) the ability to populate clinical data repositories or data warehouses by routing data from messages exchanged between other applications, 6) an established CHIN entry-point for an organization.

IEs ideally send messages following the HL7 standards. However, some Electronic Data Interchange (EDI) transaction sets, and American Society for Testing and Materials (ASTM) messaging standards are also used.

4.11 HIS Networks and Standards

Many HIS systems connect various computer systems together within the hospital and these systems branch out to terminals for end-users. Such networks in the local environment are known as Local Area Networks (LAN). However, linkages to the HIS are not limited to within the LAN. External forces are pushing the inter-networking boundaries of the HIS.

It has become difficult for hospitals to stand alone. Health care reform is driving a new health care model-- a hospital today is just one stop along an entire continuum of care that can include other providers such as physician offices, home health agencies, Preferred Provider

Organizations (PPOs) and Health Maintenance Organizations (HMOs). Local medical centers are joining together to become regional systems who are themselves tapping into national data resources to improve decision making and compare their performance to others nationwide.

Organizations must share caregiver information as patients move along the continuum. They must establish two-way links with national and regional data-bases to report and use ubiquitous data critical to ascertaining risk and providing cost-effective care. As a result, today's health delivery model is three-tiered, its orientation radiating outward from the local, stand-alone organization to the regional, community-based system to the national governing organization.

The following section examines some of the network technology being used to establish these Local Area Networks (LANs), Metropolitan Area Networks (MANs), and Wide Area Networks (WANs).

4.11.1 Ethernet, A Local Area Network Technology

Ethernet is a LAN technology that transmits information between computers at speeds of 10 and 100 million bits per second (Mbps). A LAN is defined as a privately owned data communications system that usually covers a relatively limited territory, hence the term "local area."

There are several LAN technologies in use today, but Ethernet is by far the most popular. Networking vendors estimate that as of 1994 there were nearly 40 million Ethernet nodes installed worldwide. The widespread popularity of Ethernet ensures that there is a large market for Ethernet equipment, which helps keep the technology competitively priced.

Currently the most widely used version of Ethernet technology is the 10-Mbps twisted-pair variety. The 10-Mbps Ethernet varieties include the original thick coaxial system, as well as thin coaxial, twisted-pair, and fiber optic systems. The most recent Ethernet standard is the 100-Mbps system which is based on twisted-pair and fiber optic media.

The ability to link a wide range of computers using a vendor-neutral network technology is an essential feature. Most LANs today support a wide variety of computers purchased from different vendors and require a high degree of network interoperability, which Ethernet provides.

For more information on Ethernet, see the on-line quick reference book, by Charles Spurgeon, through the WWW URL: http://wwwhost.ots.utexas.edu/ethernet/descript-10quickref.html.

4.11.2 ISO's OSI Model

ISO's OSI (Open Systems Interconnection) has established a non-proprietary communication reference model, split into seven layers, from physical cable definitions up to distributed databases and information systems, together with management and security tools. OSI data is available at the following URLs:

{http://cio.cisco.com/warp/public/535/2.html}
{http://www.adc.com/~don/osi/osi_1.html}--very good,
use as Appendix *, OSI Reference Model
{http://www.adc.com/~don/tech.html#tut}

4.11.3 Asynchronous Transfer Mode (ATM) Networks

In some multi-hospital networks, ATM technology is being used as a basis for sharing information along the continuum of health care. ATM allows interoperability of information,

regardless of the "end-system" or type of information. ATM is an "emerging technology" driven by international consensus, not by a single vendor' s view or strategy.

Historically, there have been separate methods used for the transmission of information among users on a LAN, versus "users" on the WAN. This situation has added to the complexity of networking as user' s needs for connectivity expand from the LAN to metropolitan (MAN), national, and finally world wide connectivity. ATM is a method of communication which can be used as the basis for both LAN and WAN technologies. It is felt that over time as ATM continues to be deployed, the line between local and wide networks will blur to form a seamless network based on one standard-ATM.

Today, in most instances, separate networks are used to carry voice, data and video information-mostly because these traffic types have different characteristics. For instance, data traffic tends to be "bursty"-not needing to communicate for an extended period of time and then needing to communicate large quantities of information as fast as possible. Voice and video, on the other hand, tend to be more even in the amount of information required-but are very sensitive to when and in what order the information arrives. With ATM, separate networks will not be required. ATM is the only standards-based technology which has been designed from the beginning to accommodate the simultaneous transmission of data, voice and video.

4.11.4 Fiber Distributed Data Interface (FDDI) Networks

The high bandwidth technology provided by fiber optics, opens up new opportunities for very high multiplexed data rates. Rapid advances in this field will provide not only higher data rates for LANs but for the largest networks including the Internet. Fiber Distributed Data Interface FDDI networks will be growing rapidly where current bandwidth is limiting system performance. Fiber is ideal for the distribution of pathology images where the large bit counts demand wide bandwidth for reasonable response times.

4.12 HIS Systems (Civilian)

According to Ms. Donna Palumbo, Marketing Support Specialist, of Keane, Incorporated--a firm which markets HIS systems--the top four HIS Vendors are ranked as follows:

1) HBO & Company (Atlanta, GA)
2) Shared Medical Systems Corporation (Melvern, PA)
3) Medical Information Technology, Inc. (Westwood, MA)
4) Keane, Inc. (Boston, MA)

The following is a brief overview of these firms.

4.12.1 HBO & Company (HBOC)

HBOC is a healthcare information solutions company that provides information systems and technology for the health enterprise--hospitals, integrated delivery networks and managed care organizations. HBOC claims to offer products and services to meet virtually every need that the enterprise has for information, whether patient care, clinical, financial, or strategic management.

HBOC markets local, metropolitan and wide area network services; HBOC's client/server-based Pathways 2000 suite of applications provide key elements for integrating and uniting providers across the continuum of care and establish the infrastructure necessary for a lifelong patient record. Its hospital-based STAR, Series and HealthQuest transaction systems and TRENDSTAR decision support system--along with the clinician-focused Pathways 2000 products--help improve the delivery of health services to an entire community. The Pathways 2000 resource

scheduling and managed care solutions and QUANTUM enterprise information system support the critical business functions necessary to manage today's emerging health networks. In addition, agreements and alliances with business partners allow HBOC to offer a broad variety of complimentary applications and technology, such as physician practice management systems.

HBOC wraps these products with such services as planning, implementation and support, plus education and training. HBOC also offers a range of outsourcing services that includes strategic information systems planning, data center operations, receivables management, business office administration and major system conversions.

4.12.1.1 HBOC's Network Solutions

HBOC has noted that healthcare is drastically changing in the way it conducts its business. Fee-for-service is giving way to managed care and competition. Stand-alone hospitals are being incorporated into health enterprises. Wellness is being measured by outcomes rather than amounts of care and patient chart size by transmission time rather than page count.

With such change, HBOC is attempting to address the following information requirement issues: 1) How do organizations share information among the many new players in a managed care environment? 2) How do they provide meaningful information for universal access throughout the facility? 3) How do separate organizations exchange the information required for a true computer-based patient record? 4) And how does any healthcare entity avoid system obsolescence in a technological environment that's advancing exponentially? 5) How do organizations build an information infrastructure to support a rapidly and constantly changing environment?

HBOC has formed "HBO & Company's Connect Technology Group" (CTG) to address the aforementioned issues based upon the conviction that retrieving, integrating and presenting information from disparate sources to an expanding variety of users will become critical in the new world of healthcare--and that networks will make these tasks possible. CTG has more than 20 years of healthcare industry knowledge, more than 100 healthcare network installations, advanced networking expertise and "proven experience" in providing information.

4.12.2 Shared Medical Systems Corporation (SMS)

Unfortunately, SMS only sent to Kensal Corporation literature describing their SMS OPENLab, a client/server laboratory information system (LIS). Since an LIS is a subset of an HIS, a brief overview of SMS and their OPENLab system is presented.

Apparently, SMS has been in the healthcare information systems industry for 25 years.

4.12.2.1 Voice Recognition and Multimedia

SMS OPENLab supports voice recognition and multimedia technology. Examples of multimedia features include on-line Help, CD-ROM reference manuals, scanned images for user-tailored Help files, full motion video and potential links to hospital satellite connections for remote training sessions, documentaries and network-wide continuing education and training opportunities.

4.12.2.2 Encoding Enterprise Rules

OPENLab automates administrative tasks and exception alerts while eliminating redundancy. Operational and clinical rules capabilities are embedded into OPENLab. For example, users can set up results reporting based on criteria such as location, choice of print

media, day of the week or time, to ensure that results are delivered to the appropriate clinicians immediately and in the format they desire.

4.12.2.3 Open Systems Approach

OPENLab is based on an open system approach, enabling users to choose the technology and operating system that best fits their needs. Users may use off-the-shelf software such as report writers, spreadsheets, databases and word processing applications. Optionally, an OPENLab system includes an HL7/ASTM compliant interface engine to optimize network and system communications. Further, full support of point-of-care testing devices, faxes, printers and pagers in physician offices is provided.

4.12.2.4 Ad-Hoc Reports

Users can define ad-hoc report formats which integrate data, text, and graphical representation of results. The need for ad-hoc reporting was underscored by SMS since the laboratory marketplace is constantly changing. "Microsoft Access" was cited as an example of a "canned-package" that combines the power of a relational database with an easy-to-use graphical report writer.

4.12.2.5 Augmentable On-Line Help

Context sensitive on-line help can be augmented to include standard operating procedures, scanned images, CD-ROM reference manuals, and multi-media capabilities with full motion video. SMS claims that "any number of third party packages" may be used to include text and graphics into the Help feature.

4.12.2.6 On-Line Screen Editing

Rather than contracting SMS to alter screens every time a change is needed, an on-line screen editor is available which enables a user to tailor screens to meet individual specifications, improve system flow, and user productivity. The reconfigurable features are: the prompt text, tabbing sequence between fields, and the layout of fields over one or more screens. Changes can be executed throughout the system without bringing the OPENLab system down.

4.12.2.7 Flexible Human Interface

OPENLab is GUI-based, multitasking compliant, and has user-definable security levels. In addition to support of mice, track balls, keyboards, and "hot keys"--light pens and touch-screen data entry options are available. A common user-interface model may be applied over the client/server technology; however, entity-specific (client) tailoring is allowed for improved end-user throughput.

4.12.2.8 Platform and Network Hardware

PC, IBM RISC System/6000, Digital VAX/VMS, Alpha, HP, Ethernet LAN

4.12.3 Medical Information Technology, Inc. (MEDITECH)

MEDITECH is a software and service company who develops, installs, and supports information systems for health care organizations of all sizes. MEDITECH emphasizes their technical innovation such as the new Handheld Point of Care Computer, and their "enterprise-wide computerized patient records." MEDITECH offers perpetual license agreements, periodic

enhancements, ongoing education, and free system upgrades so customers can migrate to new technologies as they develop.

MEDITECH has 700+ installations (as of 1994) worldwide, with a majority of the customers located in the United States, Canada, and the United Kingdom. MEDITECH has averaged more than 80 new customers annually during the past five years.

Led by CEO A. Neil Pappalardo, MEDITECH has 1,300+ health care technology professionals at its five office sites outside Boston, MA. The staff is characterized by low turnover and "uncommon commitment" to the company.

MEDITECH emphasizes a flexible, integrated approach to information systems which provide patient-based information, open systems connectivity, and easy to use decision support tools necessary for today's community health care enterprises.

Clients may build information networks comprised entirely of MEDITECH applications or combine MEDITECH's modules with other vendor's products in open networks.

MEDITECH claims to place "up-to-the-minute information in the hands of care providers throughout a health care network, regardless of whether those providers work in hospitals, clinics, nursing homes, physicians' offices, or patients' homes."

MEDITECH boasts a design principal which mandates that information systems be easy to use. One example they point to is their PCI (Patient Care Inquiry) product, used by many physicians, and can "literally be learned in five minutes."

MEDITECH is a "financially stable company dedicated exclusively to the health care market." They pursue steady, long term growth rather than rapid expansion.

4.12.4 Keane, Inc.

From Keane's Corporate Introduction (#040195C): "Keane, Inc. designs, develops and supports software for corporations and healthcare facilities. John F. Keane founded the company in 1965 as a sole proprietorship and in 1967 incorporated the company in Massachusetts. Keane has since grown into a $350 million company with over 4,000 business and technical professionals. Headquartered in Boston, Massachusetts, Keane provides services across a network of over 40 branch offices throughout the United States and Canada.

"Keane's initial corporate objectives were to assist companies in the design, development and implementation of computer systems and provide project management services to Fortune 1000 firms. Keane is now also well known for its project management methodology, Productivity Management and for the ability to complete even the most complex projects on time and within budget.

"Keane's mission is to help organizations leverage their software assets and resources to achieve their business objectives. Keane strives to build long-term, mutually beneficial relationships with its client companies by effectively addressing their software development needs. Keane's success in meeting their needs has enabled the company to derive more than 90% of its annual revenue from existing clients. It has also resulted in Keane being recognized as one of the best managed small companies in the United States by publications such as Business Week, Forbes, Financial World and Investors Business Daily.

"Keane has two operating divisions: the Information Services Division (ISD) and the Healthcare Services Division (HSD). ISD provides custom applications software for corporations

with large and recurring software development needs. Application software development includes systems planning, analysis, design, and maintenance. ISD also provides project management and help desk out-sourcing for clients.

"Keane's Healthcare Services Division develops and supports a full line of UNIX-based 'open' hospital applications including Patient Management, Financial Management, Patient Care and Clinical Systems. The Leadership Plus Series, a PC-based Long Term Care solution is Keane's offering for the long-term care market.

"Headquartered in Melville, New York, the Healthcare Services Division has branch offices in Hunt Valley, Maryland, and Los Angeles, California."

4.12.4.1 Healthcare Services Division Overview

From Keane's Division Overview (#070695C): "The Healthcare Services Division represents Keane's continuing commitment to bringing state-of-the-art application software and services to the healthcare industry. With technical, consulting, and management experience dating to 1975, Keane has grown to be a top provider of healthcare information systems in a very unstable marketplace.

"During Keane's early years, the healthcare unit experienced rapid growth by providing facilities management and assuming full responsibility for a hospital's information system needs, supplying the software, hardware, and the management and technical personnel needed to operate the hospital's information system.

"In 1984, Keane made its software available as a turnkey package. This full line of modular, yet integrated, software applications solidified Keane's reputation in the marketplace. In April of 1992, Keane acquired Ferranti Healthcare Systems Corporation, a software provider for acute-care hospitals and long-term care facilities. This acquisition expanded Keane's geographical presence in the acute and rehabilitation hospital market and added approximately 300 long-term care clients with 700 facilities located across the United States. In August of 1993, Keane acquired the software and selected assets of Professional Healthcare Systems, Inc. headquartered in Los Angeles, California. This acquisition brought to Keane a prestigious client base, including large teaching hospitals and several large healthcare chains. In April of 1995, Keane acquired the Infostat division of Community Healthcare Computing, positioning Keane among the top healthcare information systems vendors in the country and increasing Keane's install base to over 230 hospitals.

"Keane currently markets and supports a full line of information systems for the healthcare environment:

Threshold:	A comprehensive hospital information system, uses open system computing technologies that combine RISC-based hardware, the UNIX operating system, a fourth generation programming language, and a relational database management system.
Patcom:	a proven, highly rated Patient Management System designed for large teaching hospital and multi-entity facilities.
Leadership Plus:	the premier financial and resident care system for long-term care facilities.

"In addition to application software, Keane offers support services that include new enhancements to meet changing regulatory requirements, hot-line, and remote diagnostics. Keane continues to offer both facilities management and transition management that provide either long-term or short-term on-site system support, training and management.

"Keane's current management team, with and average of twenty years of experience in healthcare information technology, has been working as a unit for more than fifteen years. Keane is known for its ability to provide a total solution including software, implementation, hardware, training, and documentation."

4.13 HIS Systems (Military)

The US military has standardized its HIS installations around the world through two systems: the Composite Health Care System (CHCS) developed by SAIC (Science Applications International Corporation) and the Decentralized Hospital Computer Program (DHCP) developed by the Veterans Administration (VA) Hospital.

4.13.1 Science Applications International Corporation (SAIC)

Science Applications International Corporation (SAIC), a privately owned defense contracting company headquartered in San Diego with 19,000+ employees nationwide, enjoyed $1.9 billion in revenues for FY94 with 86% coming from the federal government (USA Today, August 21, 1995). Outside the national security community, few have heard of SAIC.

Founded in 1969 by J. Robert Beyster, SAIC's principal product is brainpower. It acts as a systems integrator to design solutions to the government's toughest technology problems. SAIC's past projects include designing one of the early "star wars" antimissile defenses, the FBI's computerized fingerprint-identification system, and plant monitoring equipment for power plants. SAIC has also designed and built the <u>largest hospital information system in the world</u> as well as the <u>largest medical telecommunications system in the United States</u> (SAIC 1995 Annual Report). Recently, in a telemedicine experiment, SAIC helped link physicians aboard a hospital ship off the coast of Haiti with major U.S. military hospitals. As a result, the ship's doctors were able to give U.S. soldiers better medical treatment. Finally, SAIC's newest DoD health care contract involves building community networks linking military medical facilities with civilian providers and VA medical centers.

4.13.1.1 SAIC's Composite Health Care System (CHCS) Program

The Composite Health Care System is funded through a $1.1 billion contract, SAIC's largest program. CHCS fundamentally is an automated network handling military health care, including patient scheduling, admissions, prescriptions, lab tests, and record keeping and was developed from close cooperation between the Pentagon and SAIC. CHCS has been installed in over 600 medical facilities worldwide and is also used in mobile units such as the one deployed in Gutanamo Bay, Cuba.

4.13.1.2 The Mission of the Department of Defense in Health Care

The mission of the Department of Defense (DoD) health care system includes maintaining the health status of the military force (including family members and retirees and their family members) by providing cost-effective, high quality inpatient and outpatient medical and dental care and maintaining medical readiness to support mobilization. It includes all inpatient medical facilities and all significant outpatient facilities, to include care delivery in the military theater and veterinary services.

Medical data processing capabilities are being acquired to assist the health care providers and administrators in the management and delivery of quality care to the patient population served within the DoD health care system. A flexible solution is being provided in medical data processing capabilities for all DoD medical treatment facilities (MTFs). Both large and small MTFs will be supported via a standard Composite Health Care System (CHCS). The architecture design involves

an integrated hardware and software solution, fully scaleable to the range of DoD medical facilities, from small stand-alone facilities to large regions and outpatient catchment areas (OCAs).

4.13.1.3 CHCS and MEDSITE (MEDical Systems Implementation and Training)

Approved by the Air Force Surgeon General in March 1993, MEDSITE's mission was to deploy CHCS to those Medical Treatment Facilities (MTFs) which had existing Initial Operating Capability (IOC) systems (TRIPHARM, TRIRAD, TRILAB, TRIPAS).

When PC-CHCS was approved for accelerated deployment to all other MTFs, Lt. Gen. Sloan approved a ramp up of MEDSITE and Standard Systems Center (SSC/SBM) to deploy CHCS Patient Appointing and Scheduling (PAS), Patient Administration (PAD), Managed Care Program (MCP) and Pharmacy (PHR).

SSC/SBM hired 4 of 38 needed term employees to deploy PC-CHCS to 29 MTFs in eastern CONUS/USAFE. MEDSITE hired 54 term employees to deploy PC-CHCS to 30 MTFs in western CONUS and PACAF, to manage the PC-CHCS project and to operate an AF CHCS Support Center.

MEDSITE currently maintains a software team which develops interfaces between CHCS and other various medical information systems, as well as report generators and other specific modules. Some interfaces are developed as a final deployable product while others are developed as a prototype effort to provide a proof of concept and provide a better understanding of the level of effort required to develop a fully functional interface for the system in question. The team also develops hard coded report modules in situations where using a generic ad hoc report generating tool is ill suited to the task either because of complexity or performance.

MEDSITE maintains WWW pages at URL: http://bender.brooks.af.mil/

This server has descriptions and M source code of the public domain software that is currently available from MEDSITE, and to be developed in the future. Some of the interfaces that have been developed are:

Telephone Refill
TransLux DataWall
Pyxis Medstation ADT
Provider Workstation Results Retrieval
TRAC2ES Patient Movement Request
MICROMEDEX

Some of the report generators that have been developed are:

Pharmacy Cost Reports
Medicare Eligible Cost Reports

MEDSITE's deployable systems have been installed at:

Guantanamo Bay, Cuba - (Operation Sea Signal)
Zagreb, Croatia - (UN Protective Forces)

MEDSITE's required future work includes:

Deploy CHCS LAB to all AF MTFs by Dec 95
Deploy CHCS RAD and Order Entry by Dec 96
Support training for software upgrades for existing MTFs

Future work for MEDSITE may also involve becoming or forming an executive agent for the Consolidated Medical Systems Support Center (COMSSC) .

4.13.1.4 Case Study of Remote USAFB CHCS Site: Guantanamo Bay, Cuba

This section will provide excerpts from a May, 1995 USAF "After Action Report" which describes the humanitarian-mission/medical-effort carried out recently in Cuba, code-named "Operation Sea Signal". These excerpts will serve to explain how CHCS was deployed in a mobile context and what the various camp implementation issues were for that context.

Excerpts From Executive Summary of Operation Sea Signal

As part of Operation Sea Signal humanitarian mission, the Joint Task Force (JTF) 160 Surgeon General (SG) was responsible for the care and support of the 21,000 Cuban migrants and approximately 500 Haitian migrants housed at the Guantanamo (GTMO) Bay encampments. Specifically, the medical care for the migrants was provided by the 6th and 59th Air Transportable Hospitals (ATHs). There was a wide range of medical services provided by these ATHs.

There was little automation deployed with the 6th and 59th ATHs. The requirements for basic medical automation in an ATH are the same as any fixed medical treatment facility - pharmacy, lab, radiology, results retrieval, patient registration and electronic mail. The purpose of this deployment was to support these basic requirements as well as validate new requirements specific to a deployed unit.

The major deficit in GTMO and within the ATHs was the lack of any type of computer/communications infrastructure. Naval Base (NAVBAS) GTMO had a wide area network (WAN) but the ATHs were not located in any area easily linked to this WAN. Secondly, the telephone infrastructure was saturated. Within the ATH, administrative duties were accomplished through the use of personal laptop computers that people had brought from home stations. After 11 months of use, they were beginning to break down and there was much concern about replacements. Telephones were limited to "field" phones linked by 4-wire tactical lines. At the 6th, there was not any link to electronic mail within the ATH or a link into the Internet. At the 59th, located across the street from the Camp Bulkeley J-6 (USMC), they had found a means to link up to the J-6 Banyan Vines server through tactical wire to provide them with access to e-mail at home. The 59th had no connectivity within the ATH. The pharmacy at the 6th ATH had brought Z-248 Tri-Service Micro Pharmacy System (TMPS) but they continued to have breakdowns. The 59th ATH did not have TMPS but did have the capability to use a personal computer (Z-248) with Pharmacy Label Producing Software (PHLAPS) for printing prepack labels.

MEDSITE's deployment of the Composite Health Care System (CHCS) to GTMO Bay was prompted by a request from the pharmacist assigned to the 6th ATH. After receiving approval from the ATH Commander, the JTF/SG, USACOM/SG, and the AF/SG, MEDSITE put together an DEC Alpha AXP capable of supporting a minimum of 25 concurrent users and enough disk storage for one year of on-line data. The system was installed in the 6th ATH with plans to tie all medical activities together.

Deployment Strategy/System Configuration

MEDSITE deployed a DEC Alpha (AXP) 3000/300 with CHCS Version 4.2/MU2 software. Peripheral hardware included DEC VT 320s, LA75 text printers, and Data South 300 XL label printers. Connectivity was via Local Area Transport (LAT) using DECServer 300s. Connectivity to outside locations was accomplished by connecting line drivers and bridges/routers through phone or tactical lines. Other specifics for hardware are listed below:

Product or Function	Item
CPU	DEC Alpha AXP 3000/300 RISC based 125mHz
DEC StorageWorks	1.5 GB DAT backup storage tape 1.2 GB Disk Drive CD-ROM
Memory	64 Megabytes RAM
Disk Storage	20 Gigabytes (10 - 2.01GB disk drives)
Backup	Disk to Tape Disk to Disk
Operating System	OpenVMS Version 6.1
Software	DSM Version 6.3d CHCS Version 4.2/MU2
Other	TGV Multinet PWS/TRAC2ES Interface software

Communications

The AXP only has a 10BaseT connector and the DECServer only has a 10Base2 connector. A Boca Hub with a 10BaseT and 10Base2 was used to connect the AXP with the DECServer 300s. Running 6-wire unshielded twisted pair within the 6th ATH, VTs and printers were connected to DECServer 300s.

A link between 59th to JTFJ6 already existed. The Camp Bulkeley J6 (USMC) had connectivity between their Banyan Vines server and the JTFJ6 Banyan Vines server in the Pink Palace. A tactical line from the 59th ATH had been run across the street to the Camp Bulkeley J6. Since the JTFJ6 at the Pink Palace was linked to the Internet, both the 59th and the Bulkeley J6 were linked to the internet. The goal was to link the 6th ATH into the same Banyan Vines server at the Pink Palace so we could access either the internet or the 59th ATH. If the NAVHOS (Naval Hospital) GTMO had access to the internet then we could theoretically access them once we were on the internet.

Linking the 6th ATH to the JTFJ6 Banyan Server. The Navy Communication Detachment (NAVCOMMDET) at GTMO provided two cable pair that we used to attach two AT&T 3510 line drivers and two DECrouter 90T1 bridge/routers. One end was attached to CHCS via the Boca Hub while the other router and modem were attached to the JTFJ6 Banyan Vine server. We had continuous problems with keeping the link up between the two modems. When the link was up we were able to telnet to the Banyan router and get to the internet.

Linking the 6th ATH to Camp Clinics (first is Lima/Mike camp) and the 59th to Camp Clinics (first is Echo/Foxtrot camp). Although two Codex 3500 line drivers were taken to connect Lima/Mike with the 6th, they were never tested because the lack of cable pair or commercial phone lines going to these clinics. A link in the future would require some type of wireless technology. LCDR Tillery and LT Welch visited from Naval Medical Information Management Center

(NMIMC), they had discussed the installation of a cell on one of the hills and using cellular phones/modems to hook up the ATHs with their outlying clinics.

Connect to NAVHOS GTMO. The 6th ATH and the NAVHOS were both able to provide a single phone number that allowed modem access between the two facilities. Although not very fast we were able to link the NAVHOS Lab to CHCS using a pair of 2400 baud modems. Although we had taken 9600 baud modems we were unable to get the DECServer 300 to talk to them. Between the Pink Palace, Deer Point, and NAVHOS there is a clear line of site which is less than 4 miles total distance. Wireless technology could be used in the future.

4.13.1.5 CHCS Advantages

Results that were being recorded on separate log sheets and log books can now be found and printed in a collated report in less than five minutes compared to 20 minutes or more without CHCS. All specimens entered into CHCS were immediately accompanied by an audit trail providing positive specimen tracking. In addition special reports such as the Pending Lists, Overdue Procedure Reports, and Uncertified Results Report provided lab management an easy way to monitor the status of any test and take corrective actions to ensure results are returned in a expeditious manner not lost in a mountain of loose papers. Results were accessed from anywhere in the ATH there is a terminal, not just at the laboratory. This reduced the amount of time wasted walking to the lab to research what happened to a result. Electronic mail was used to pass information on protocol changes to different shifts, easing dissemination of critical operating policies.

4.13.1.6 CHCS In Emergency Unit

A CHCS terminal was placed in the Triage area (open tent adjacent to ER). This allowed the ER tech to triage the patient, take vitals, and print the 558 to the main ER. Changes were made to CHCS to allow the triage technician to enter directly into CHCS the patient's vital signs and to add comments he wanted to pass on to the ER. Once complete the 558 was printed on the ER printer. The bottom of the 558 was also changed to allow the understanding statement to print in Creole or Spanish.

An Information Desk Display was added to the Emergency Room main menu to allow for easy and fast look up of admitted patients.

4.13.1.7 DMPITS Database Conversion

Patient tracking was a problem at the ATHs. Some sections were using the US Atlantic Command (USACOM) developed Defense Mass Population Identification and Tracking System (DMPITS). There were multiple problems identified with DMPITS: (1) lack of confidence in the data accuracy because registration information was not verified at the time enrollment; (2) lack of devices in each section (many of the devices were broken and did not work); and (3) the DMPITS was not on a network, leaving each section to build their database. DMPITS was updated manually once per week based on data provided to a central location. CHCS would provide a means for accurately tracking patients through the ATH as all would use one central patient database.

The DMPITS office provided a DOS "flat file" containing the Name, DMPITS Number, Date-of-birth, Sex, Camp, Tent, and Bed. This file was transferred to the Alpha using a laptop computer. A conversion program was written in MUMPS to read the file and insert the data elements into the CHCS database providing pre-registration for all migrants.

4.13.1.8 *After Action Conclusions*

The DEC Alpha proved to be the ideal platform for simplified system management required for a deployed system. A single CPU system eliminated the problems with database synchronization and greatly simplified back-up procedures. The performance was excellent and better than expected. Any deployable system should be fully scaleable if future upgrades become necessary. Finally, the OpenVMS operating system was very robust and tolerant of unexpected "crashes" that are often a fact of life when operating in a tent environment operating off generator power. All the ATH components (CPU, DECServers, VT 320s, LA 75s) were configured at MEDSITE and tested for compatibility and reliability prior to deployment. This part of the deployment went smoothly and as predicted. However, the remote communication solutions between all the medical facilities at GTMO were not tested because the availability of the type of physical wire was unknown. In the future one needs to know the location of the nearest Wide Area Network (WAN) connection and the locations of any remote sites that will be connected to the CPU. The distances from the CPU to these locations must be known as this will drive the communication solutions. Based on this information, the team should deploy with one or more solutions for each type of remote connections. The deployment to GTMO was very successful. The ability to get daily A&D reports; the ability to track the pregnant migrant women by camp, DMPITS number, and EDC; the ability to better track and monitor drug distribution, whether by prescription or by bulk issue; the ability to quickly send panic lab values directly to the clinic or ER; and the ability to register and track patients all improved the efficiency and quality of care being given by the 6th ATH. From this test deployment, many lessons were learned regarding the flexibility of CHCS and the flexibility required to support both humanitarian as well as wartime missions. These lessons will be used to better train our people for future deployments.

4.13.2 Military and HL7

Both the CHCS and the DHCP are based on the File Manager, a set of extensions to MUMPS originally developed by the VA that facilitates data sharing among applications that are homogeneously developed using the File Manager toolset. The coupling among FILEMAN applications is very tight, being based on a shared database. The development paths have diverged, however, so that the systems are not at all interoperable.

The DoD agency that issued the contract to SAIC published a notification in the Federal Register sometime in 1993 of its intent to use HL7 in the CHCS for interfaces to third-party systems.

The VA is adapting as rapidly as it can to HL7. Its people participate in the meetings and it uses HL7 for exchange between the DHCP and third-party systems. It has even looked at HL7 as a model for inter-module data exchange within the DHCP.

5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

First, let us explain how the lensless microscope works. The basic principle of the lensless microscope is illustrated in Figure 8. The specimen to be visualized by the microscope is a tissue section mounted in the traditional fashion on a microscope slide and covered by a thin glass coverslip. Light passes upwards through the microscope slide, through the tissue, and through the coverslip. In the traditional microscope an image of the tissue is formed with an objective lens/eyepiece combination on either the user's retina or on a picture-taking device such as a digital CCD television camera or photographic film camera. The deficiency with this traditional approach is that, even using lenses with the largest field of view, only a small portion of the specimen can be visualized by the user. At lowest power, only 2% of the specimen is visible using a standard 640x480 TV camera. This increases to about 7% when using a 1000x1000 electronic imaging device.

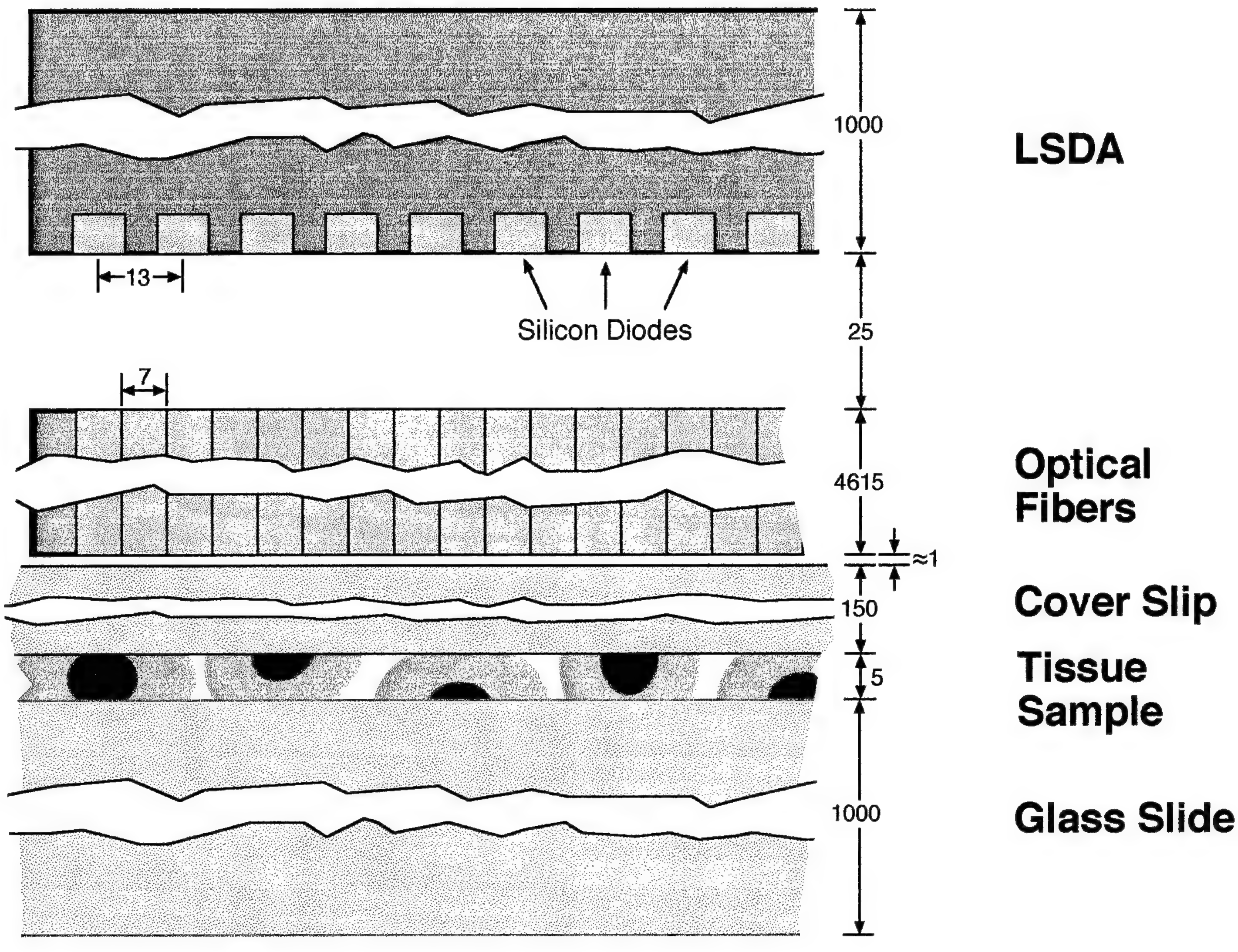


Fig. 8 - Schematic of the lensless microscope (numbers are in micrometers) .

5.1 Initial Invention

This section is quoted in part from Kensal's final report on the SBIR Phase I research project (DMI-9460231) for NSF (National Science Foundation). The objective of this research for the NSF was to investigate the possibility of quadrupling the number of picture elements per unit area in lensless microscopy. If successful, this would increase resolution to the point that this new form of microscopy would be useful in picturing all types of human tissue.

In the early 1980s the PI realized that, with advances in technology (fiber-optic couplers and linear CCD arrays with small spacings), an all solid-state microscope could be built that required no lenses and whose field of view would be unlimited. Figure 8 shows how, in such a microscope, light can be carried from the specimen, using optical fibers, to the light sensitive silicon diodes in a linear CCD array. After a patent was applied for by the PI in 1984, this idea of lensless microscopy was found to be novel and useful by the U.S. Patent Department. A patent was issued to the PI in 1988. In 1989 funds were first requested to make a demonstration by building a prototype of a lensless microscope. After many tries, a grant for a demonstration of lensless microscopy was made in 1992. Within five months, the world's first lensless microscope was built (Figure 9) and images generated. It is currently being applied to medical microscopy in the combined L/L (Lensless/Lensed) system that is under field trial in a telepathology hookup between the Mayo Clinic and Luke Air Force Base.

Using the apparatus shown in Figure 9, KSC offered to generate a lensless image of any microscope slide submitted to our laboratory. Our colleagues throughout the USA have taken advantage of this offer. Certain individuals have replied that they can in fact make a diagnosis

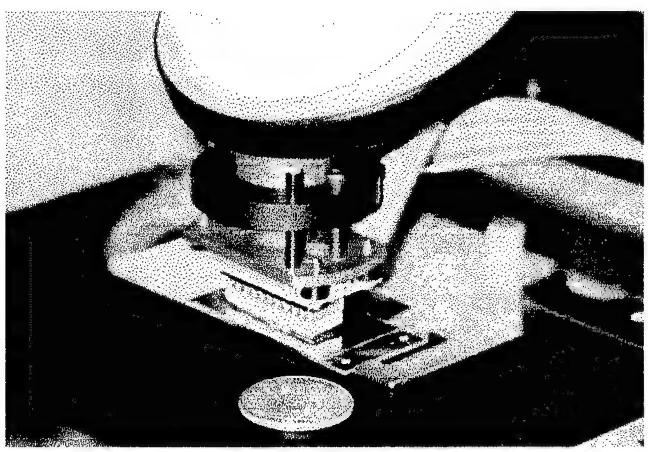


Fig. 9 - Kensal Corporation's laboratory demonstration of a lensless microscope.

from the lensless image generated by our equipment. On the other hand, others have replied that the lensless image looks so "fuzzy" that even areas of interest could not be found. These reactions tend to be tissue specific. Sections of the human lymph node appear to present the greatest problem. Dr. Bharat Nathwani (University of Southern California and the Los Angeles County Hospital) told us that, in lensless images of the lymph node, it was sometimes impossible to select areas for examination at high magnification in that distinguishing features were missing.

5.2 Resolution Improvement

Therefore, support was requested from the National Science Foundation in 1994 to allow us to work with EG&G Reticon (Sunnyvale, CA) to devise a higher-resolution lensless

microscope. We proposed that a tapered fiber-optic bundle be sliced and affixed to the original EG&G detector array to create a lensless magnifier as shown in Figure 10 having a 3.5 micrometer to 7.0 micrometer taper. The proposal was submitted in 1994 and funded in the fall of 1995. The budget allowed $13,900 for the entire diode array device. Due to several delays caused by EG&G Reticon, research was delayed and NSF extended the completion date of the Phase I research to September 30, 1996.

During this extended time frame EG&G announced a breakthrough, namely, a new product wherein the diodes themselves were spaced on seven micrometer centers. This explained why they had delayed in fabricating the diode array that used thirteen micrometer centers and the tapered fiber-optic faceplate. Unfortunately, the new diode array had an entirely different pinout. Also, instead of using two output pins for the alternating odd and even diode outputs from the linear array, a single output pin was employed with a time multiplexed odd/even output. Modifications to compensate were done by Kline Research (Reseda, California) based on parallel work being conducted for the Army Missile Command (DAAH01-95-C-R209). Within the original budget $13,900 Kensal was able to buy the new seven micrometer diode array, have new driver electronics fabricated, and a new mechanical mount for the diode array fabricated (Boeckeler Instruments, Inc., Tucson, Arizona).

Due to the time required for this major realignment of our research program, the first demonstration of lensless imaging using seven micrometer diodes was not made until the end of August 1996. The first seven micrometer images were generated at the Kline Research facilities and proved successful. Immediately the entire laboratory apparatus was transferred to our laboratory for further experiments in the last month of the grant. First, it was found that the stage velocity (controlled by a JM-1 Boeckeler Instruments Motion Controller) was misadjusted. Kensal staff worked on the software changes required to correct the motion contoller velocity and within a few days produced geometrically correct images. These showed remarkable improvement over results previously obtained from the thirteen micrometer diode array procured under our NIH grant. This advance fully satisfied the goals of the Phase I research for NSF. For example, Figure 11 is a lensless image of a matrix of 4x4 on millimeter squares taken with the original 13um scanner in 1992. Figure 12 is a lensless image of the same matrix using the new 7um scanner that was delivered to us in August 1996. The resolution improvement is obvious and dramatic. Numbers and letters that were scarcely visible in Figure 11 are clearly distinguishable in Figure 12. Thus this represents a highly important improvement in lensless scanning. The images are no longer "fuzzy" and should be interpretable by any pathologist.

5.3 Reprogramming our Research and Rebudgeting

As soon as our success on the NSF Phase I research occurred, we contacted the Boeckeler Instruments company that had fabricated the two L/L (Lensless/Lensed) workstations now deployed at Luke Air Force Base and Mayo Clinic. Boeckeler was asked to quote on a retrofit for both workstations; one with just the new diode array and the other with the diode array plus a new stage and microscope so as to prepare for the fact that microscope models in use at Mayo Clinic and Luke AFB are being discontinued. This would yield two retrofitted workstations with high-resolution (6.9 micrometer) scanners that should revolutionize their performance. The PI feels that this is essential to the success of continued research in military telepathology for USAMRMC.

In order to perform the retrofit, we are recommending a rebudgeting according to the following table. This table shows the most recently approved budget and also the revised budget that transfers funds from the tasks involving field trials in Texas (see below) in cooperating with Loral to tasks involving retrofitting the two existing workstations and planning field trials elsewhere (Section 5.4).

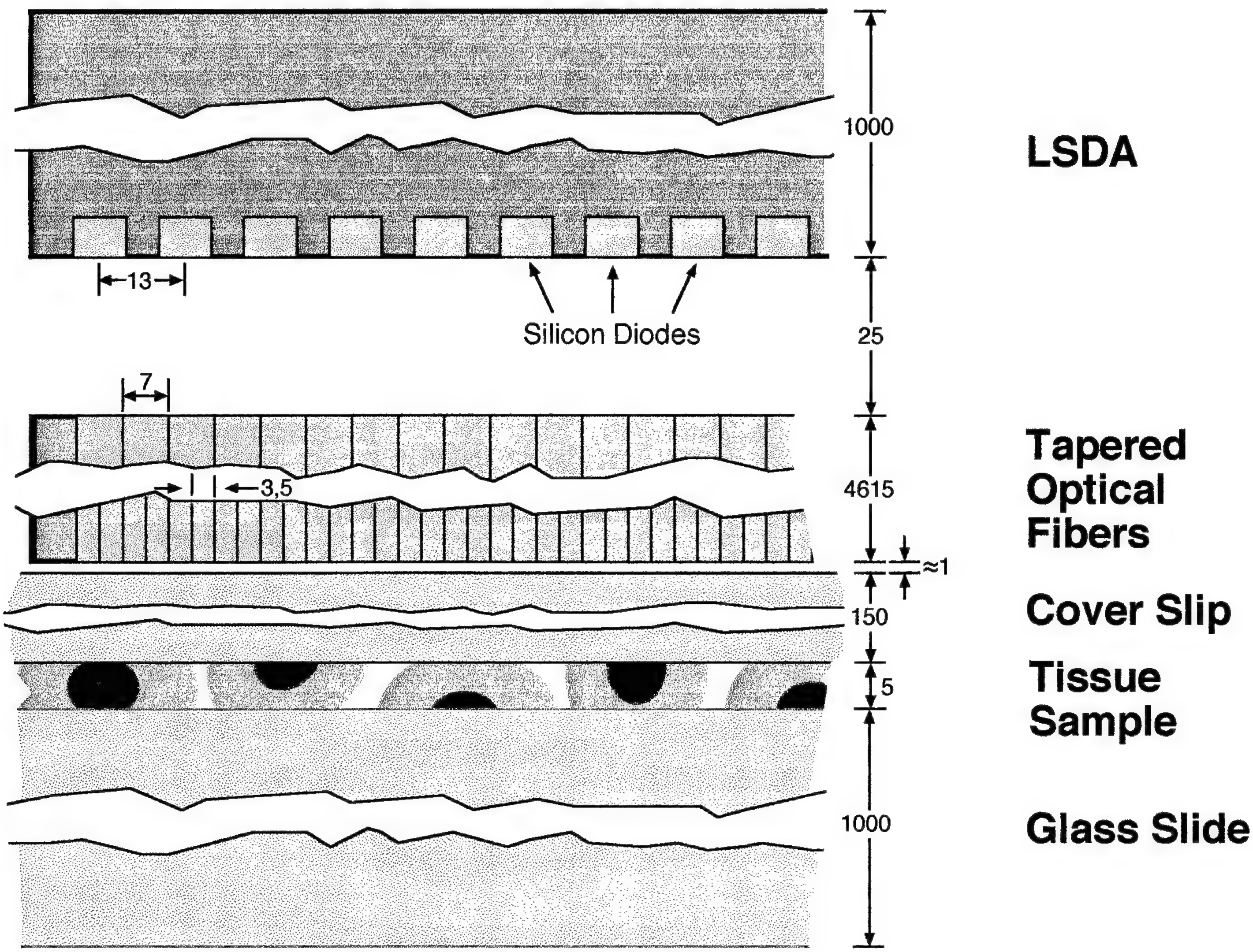


Fig. 10 - Lensless microscope with 2:1 fiber optic coupler.

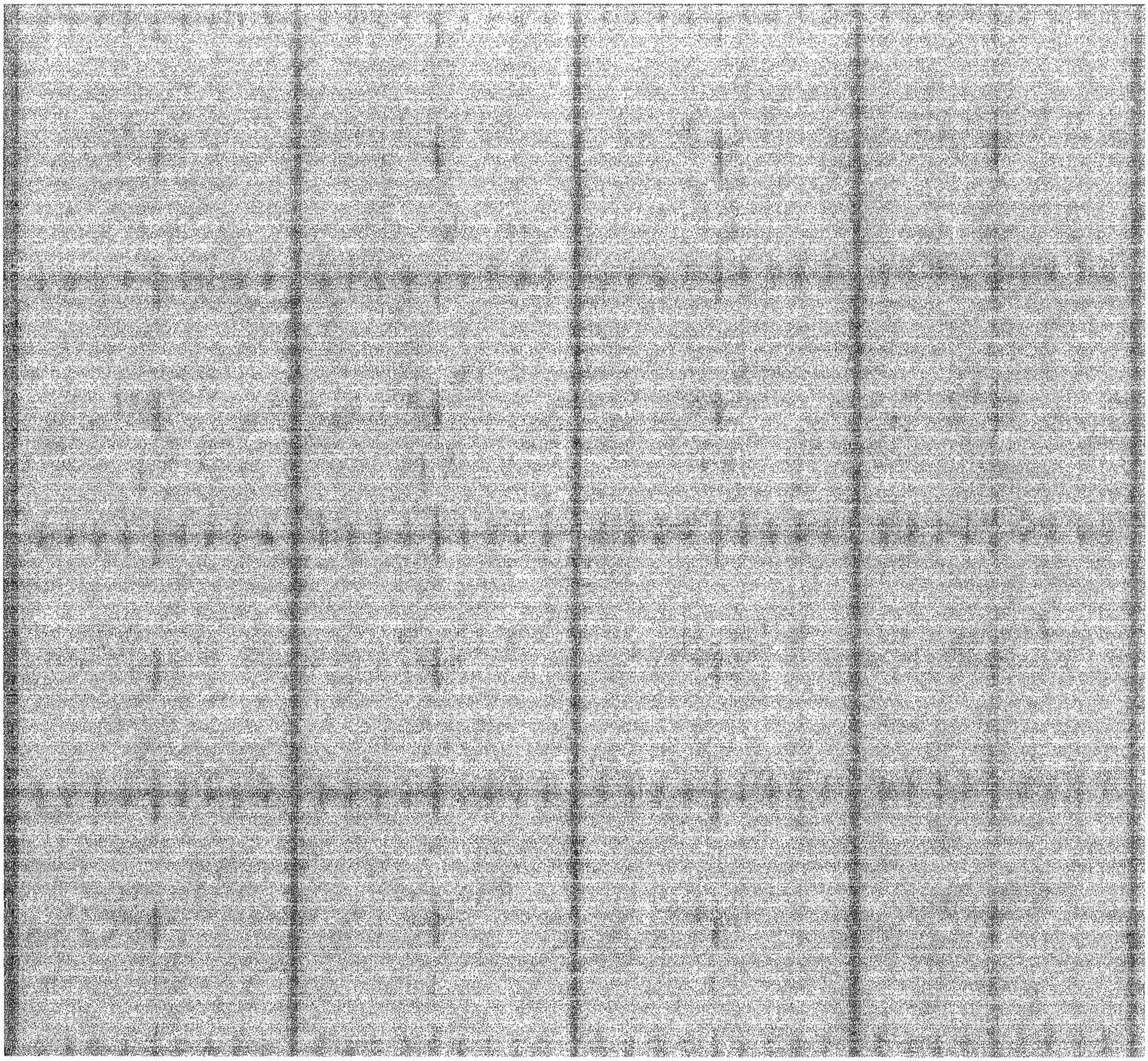


Fig. 11 - Lensless image of a 4x4 mm portion of a microscopic test pattern using a diode array scanner with 13 micrometer spacing.

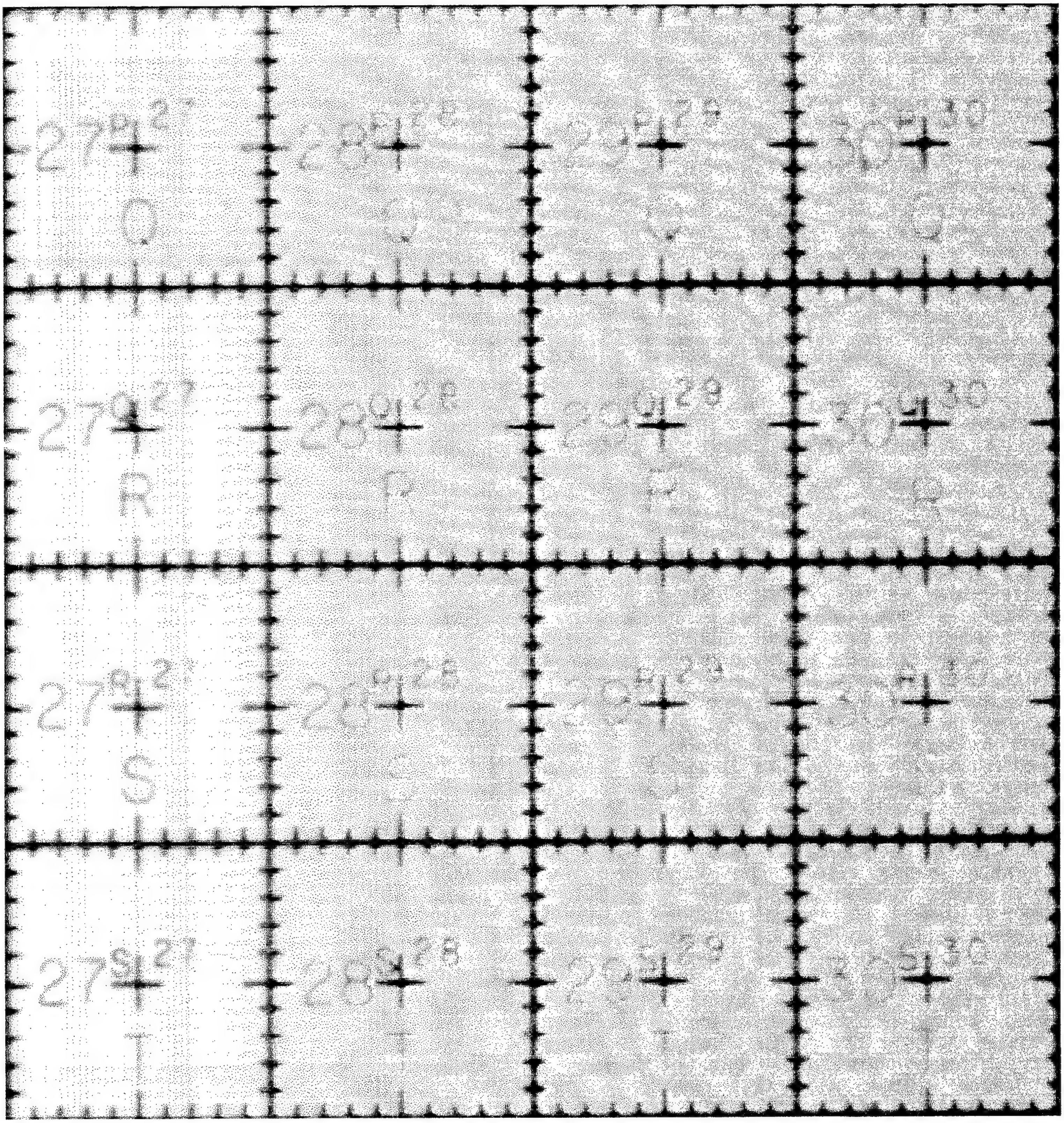


Fig. 12 - Same as Figure 11 except that the diode array uses diodes spaced at 6.9 micrometers.

		Year 2 Budget		Year 3	Year 4
		Budget (approved 12/95)	Spent	Proposed	Proposed 6 mo. Extension
1.	SALARIES (W-2 and 1099) [1]	160,000	98,715	157,562	59,581
2.	BENEFITS [1]	--	--	--	--
3.	CONSULTANTS				
	Nance [2]	27,000	--	27,000	--
	Devey [3]	--	3,667	6,000	--
	Kline [2]	--	1,800	--	--
	Deasey [2]	--	510	--	--
	Garrett [4]	--	--	14,758	--
4.	EQUIPMENT				
	PCM Assemblies, Optics, Workstations	88,804	--	--	--
	Upgrade 2 existing workstations [2]	--	--	178,673	--
5.	SUPPLIES & MATERIALS	11,281	15,975	27,218	--
6.	TRAVEL				
	PHX-SFO	1,832	--	--	--
	PHX-SAN	1,408	868	--	--
	Within Arizona	--	1,576	502	--
	TUC-LAX	--	1,058	1,500	--
	PHX-Wash. DC [3]	--	--	3,500	3,000
7.	ADMINISTRATIVE SUPPORT	--	--	--	--
8.	INDIRECT COSTS	32,629	42,904	79,492	18,525
9.	MISCELLANEOUS				
	Loral	26,300	--	--	--
	Optical Systems Corp. [5]	50,000	69,800	35,053	--
	Washington, DC location	--	--	20,000	--
10.	TOTAL COST	399,254	236,873	551,258	81,106
11.	Obligated as of 9/30/96				
	Contract Labor	--	33,800		
	Subcontract [5]	--	111,600		
12.	TOTAL COSTS PLUS OBLIGATIONS		382,273		

Notes:

[1] Kensal in some cases now supports medical insurance for certain of its employees. When this is done, costs will be taken from salaries.

[2] Proposed use of funds originally earmarked for Loral in FY1997 to upgrade software (Nance), electronics (Kline), optomechanics (Boeckeler) of existing workstations.

[3] Coordination of workstation liaison in Washington, DC.

[4] Coordination of workstation effort at Mayo Clinic and Luke AFB.

[5] Completion of PCM prototype initially contracted in FY1995.

It is clear from the images generated that a significant improvement in L/L Microscopy for military medicine would take place if the retrofit were to be implemented. Therefore, it is the Kensal Corporation's strong recommendation that this retrofit be undertaken at the earliest possible date. The budget presented above will make this possible. Implementation could start immediately when approval is received from USAMRMC.

5.4 Reorganization of Field Trials

Also, in order to satisfy DARPA's desire for field trials in Washington, this has also been addressed. Per the recommendation of Dr. Richard Satava (head of the Advanced Biotechnology Program at DARPA) we are planning to arrange a transfer of the workstation now in use at Mayo Clinic from Scottsdale, Arizona, to one of the installations with whom we have been working in the Washington area. If posssible, field trials will be arranged at more than one location. One candidate, recommended by Dr. Satava, is AFIP (Air Force Institute of Pathology). Another location where there is significant interest in our work in telepathology is the Department of Pathology, School of Medicine, Georgetown University. There Dr. Norio Azumi as well as Ms. Yukako Yagi have been working with us on comparing the partial coverslip scanner of Polaroid with the full coverslip scanner that has been developed under our NSF grant. A cross comparison of the characteristics of these two systems is given in Figures 13 and 14. As can be seen, at least for these images, the coverage obtained by the scanner at Georgetown is smaller than that obtained by our scanner. Resolution has been measured, but high magnification images have yet to be generated. The scanner at Georgetown generates about 12,000 picture points per square millimeter; the new lensless scanner, 21,000, i.e., an 80% increase in resolution.

5.5 Positive and Negative Aspects of Grant Research in FY 1996

The USAMRMC requests that each annual report summarize the year's research by giving both positive and negative aspects of the research.

5.5.1 Positive Aspects

The major positive aspect of our Year 2 research was the acceptance and certification of the two workstations for use in telepathology that we contracted to be built in Year 1 by Boeckeler Instruments Inc. These two workstations are now the <u>only two in the world</u> to combine lensless and lensed microscopy in an integrated unit for both local and remote examination of surgical specimens of human tissue. Using a workstation, both local and remote examinations may be done by the user from images displayed on a high-resolution computer screen. Remote examination requires, in addition, the use of the ISDN (Integrated Services Digital network) for image transmission. Since the second quarter of FY1996 both workstations have been deployed: one at the Mayo Clinic; the other at Luke Air force Base. To date 40 surgical specimens have been analyzed by a team of four pathologists using both local and remote techniques. The study is double blind so that, after completion, a statistical analysis may be performed (FY 1997) to determine and compare diagnostic success rates using the digital imaging workstation versus using the ordinary manual microscope.

5.5.2 Negative Aspects

First, the Boeckeler workstation installed at the Mayo Clinic has shown satisfactory performance, the one at Luke AFB has not (Section 2.2). As of mid October the Luke AFB workstation has been returned to Boeckeler for overhaul.

Second, Optical Systems Corp. has been unable to deliver PCM (PC Microscope - a significantly more compact workstation for medical microscopy) on time. Thus we have cancelled the "production order" for any other PCMs and are requesting the funds be transferred to the now far more important research in retrofitting the existing Boeckeler workstations with high resolution lensless scanners. OSC is still funded to build a single PCM prototype using funds committed to them in FY 1996. They now estimate completion in the first quarter of calendar 1997.

Third, Loral, a company that showed interest in working with us on incorporating our L/L Microscope with their MDIS (Medical Diagnostic Image System) has been merged into Lockheed

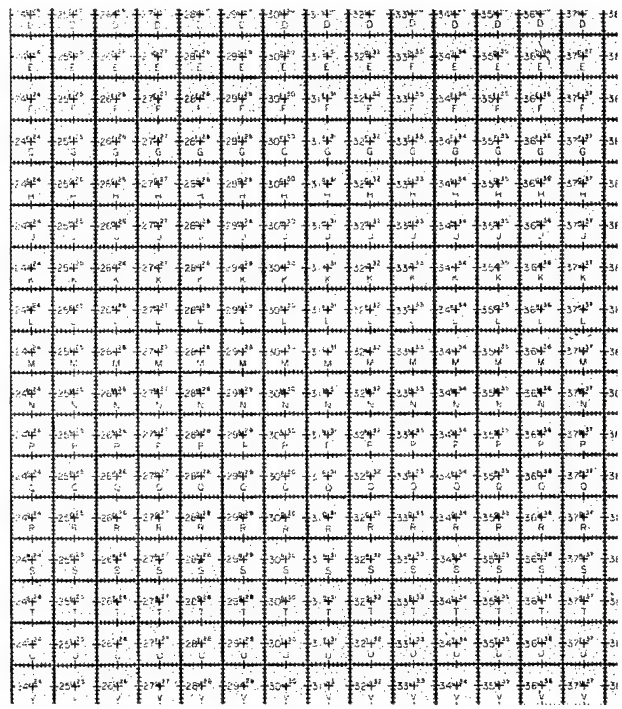


Fig. 13 - Lensed scan of test pattern microscope slide (23x44 mm) at Georgetown University. Coverage is 14.4x17.7 mm.

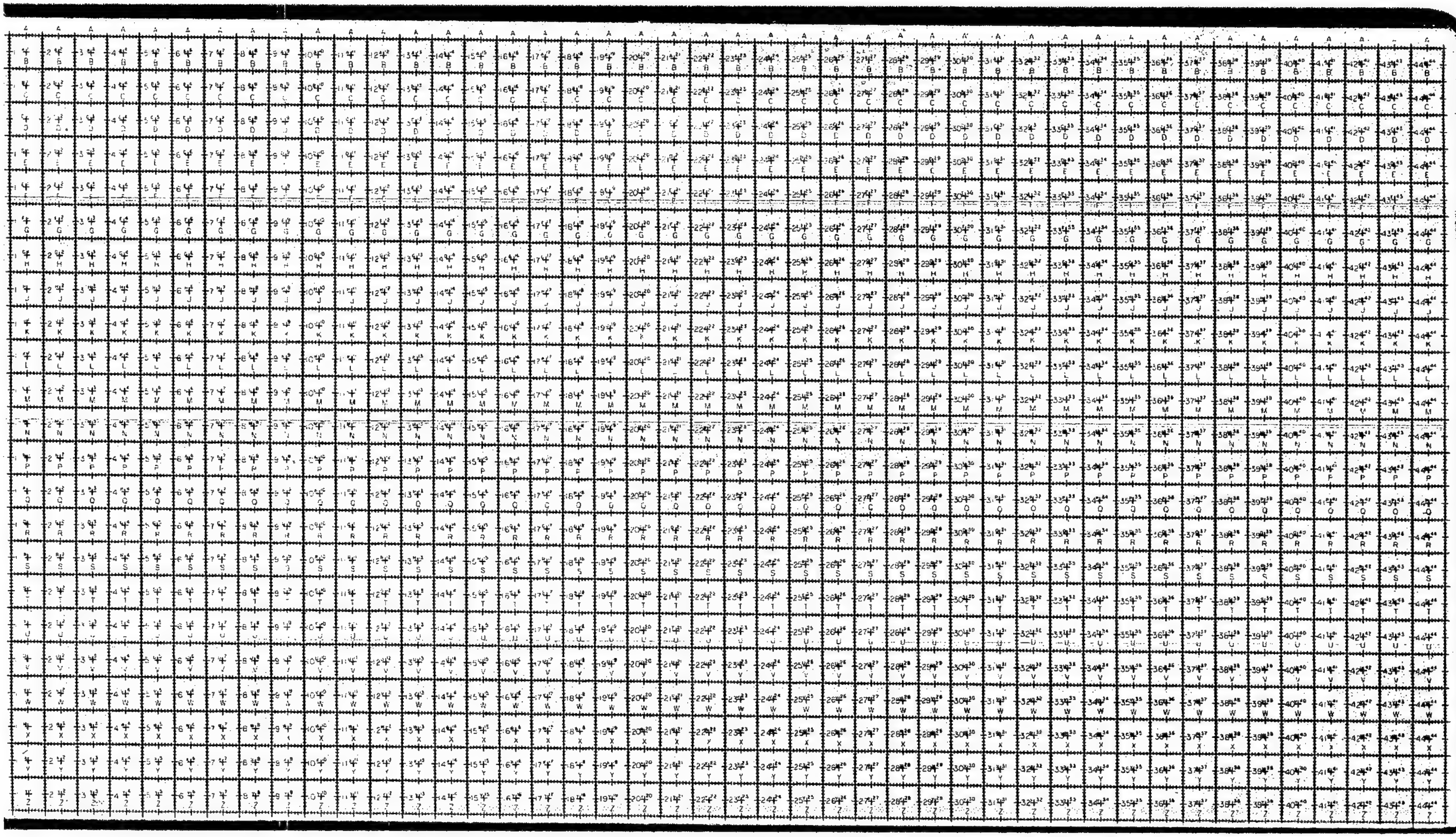


Fig. 14 - Lensless scan of 23x44 mm test pattern on microscope slides. Coverage is 100%.

Martin. Since then two telephone calls and one letter have brought no response. We feel that they must be dropped from our USAMRMC project and funds allocated be transferred to reworking the existing workstations built by Boeckeler. The strategy will be explained more fully in a separate letter to USAMRMC.

APPENDIX A

1996 HIMSS/HP LEADERSHIP SURVEY

1996 HIMSS/HP LEADERSHIP SURVEY

For better and for worse, managed care is driving health care automation. Managed care continues to be the dominant force in health care as organizations focus on the bottom line and control costs. This is according to the seventh annual HIMSS/Hewlett-Packard survey of trends in health care computing which represents the opinions of more than 1,200 participants at the 1996 Annual HIMSS Conference in Atlanta, GA. Following is a summary of major findings.

49 percent of respondents believe the need to control costs due to the continued pressures of managed care is the most significant force driving IT investments in health care. Cost control outranked other forces such as competition with other providers (20 percent) and coping with mergers and acquisitions (17 percent).

Respondents were divided over the real-life impact of managed care. While slightly more than half (57 percent) say managed care will have a positive impact on health care by either lowering costs through consolidation or improving outcomes because of heightened focus on measuring quality, a substantial minority (41percent) are worried about the negative consequences of managed care. Among all respondents, 26 percent say that business forces will negatively impact clinical practices, and 15 percent believe that patient mistrust of gatekeeper physicians will grow.

Greatest IS priorities: upgrade, integrate and re-engineer

The most important IS priorities for health care organizations are upgrading their IT infrastructure (32 percent) and integrating systems in a multivendor environment (27 percent). Reengineering to a patient-centered computing environment is also receiving priority attention from 23 percent of health care organizations. And organizations are following through by completing these projects. Forty percent of organizations have undertaken projects to upgrade their IT infrastructures and 18 percent have begun systems integration projects this past year.

Strong movement beyond hospitals' walls

Reflecting the larger trend in health care delivery, computer technology is moving rapidly beyond the walls of traditional hospitals. The two greatest departmental automation priorities for the coming year are physicians' offices (35 percent) and outpatient clinics (15 percent), far outpacing traditional inpatient settings such as critical care, OR and Med/Surgery.

Computer technology in an office or group practice setting

In the outpatient setting, the greatest advantage of information technology, according to survey respondents, is access to current patient information across the enterprise (45 percent). Other advantages cited are: automating workflow (19percent); better financial management of offices (16 percent); and better management of non-clinical patient tasks (13 percent).

IS frustrations: where's the strategy?

Three out of 10 respondents (31percent) say their organizations lack overall strategic IS plans and are too focused on tactical projects. This represents an even higher degree of strategic frustration than one year ago, when 19 percent of respondents gave this response.

Emphasizing this further, the need to develop a strategic plan was cited as the greatest telecommunications challenge by 25 percent of respondents. Other frustrations include a lack of

applications to meet the demands of clinical data repository and/or electronic medical records (18 percent) as well as difficulty in finding and maintaining a good technical staff (16 percent).

Budgets and staffing on the rise

Eight in ten respondents say their IT budgets will increase over the next two years. This year's survey indicates a small drop in significant budget increases (defined as 30 percent or more budget increase), perhaps reflecting a "coming-to-terms" with the realities of the economic constraints of managed care. In a related but somewhat surprising finding, six out of 10 respondents believe their M.IS staff will increase over the next two years. This may indicate a realignment in response to previous downsizing trends.

The Internet and The World Wide Web in health care

The revolution in cyberspace has reached health care. The HIMSS/HP survey indicates that the most common use of the Internet is for on-line clinical research services &shyp; say 56 percent of respondents &shyp; and for physician-to physician communication, say 33 percent of respondents. Health care organizations also see the promise of the World Wide Web, the multimedia section of the Internet. Thirty-six percent of respondents say their organizations have Web sites up and running; another 37 percent are currently developing sites.

CHIN fever subsiding?

Nearly three-quarters of respondents (73 percent) say their organizations do not belong to a community health information network.

Integrated delivery systems (IDS)

Sixty-four percent of respondents say they are either part of an IDS or are in the process of becoming part of an IDS. Nineteen percent are still not part of an IDS but plan to become part of one within the next year. However, these findings reflect no change in the percentages from last year's survey.

CPRs &shyp; still weighing the options

Despite significant interest in computer-based patient records, nearly six out of 10 respondents say they have made no investment or committed to funding a CPR project. In contrast, about 30 percent of respondents say they have invested heavily in the equipment and software needed to implement a CPR.

Data storage

A significant majority of respondents see an explosion in data storage requirements over the next two years: 65 percent say storage requirements will more than double, another 20 percent predict the need for at least double their current requirements, and 13 percent say the load will increase by about half of their current requirements.

Security of medical information

The bad news: eight out of 10 respondents (79 percent) are concerned about unauthorized access to computerized medical information. The good news, however, is that half of those concerned have taken steps to protect their data and the other half are planning to do so.

Data on telemedicine

Forty-one percent or respondents are at least somewhat involved in telemedicine, and another 35 percent are investigating it actively.

Praise for telecommunications reform

Sixty-four percent believe the new telecommunications law deregulating the industry will have a positive impact on health care, offering the potential of making telemedicine and videoconferencing easier than ever before. Only one in ten believe that it will have a negative impact.

Futuristic health care technologies

Half of the survey respondents agree that in the next three years access to on-line health care information and services from the home will be the most significant health care-related computer development affecting the average consumer (48 percent).

APPENDIX B

GLOSSARY OF ACRONYMS

Glossary of Telemedicine and Hospital Information Related Systems Acronyms; 11/1/96

No.	Acronym	Definition
1	AAMT	American Association for Medical Transcription
2	AAPA	American Association of Pathologists' Assistants
3	AARP	American Association of Retired People
4	ABI	Application Binary Interface
5	ABP	American Board of Pathology
6	ACGIH	American Council of Government and Industrial Hygienists
7	ACH	Automatic Clearing House
8	ACR	American College of Radiology
9	ADA	American Dental Association
10	ADC	, Analogue to Digital Converter
11	ADT	Admission Discharge Transfers
12	AHIMA	American Health Information Management Association
13	ALA	American Library Association
14	AMA	American Medical Association
15	ANA	American Nurses Association
16	ANSI	American National Standards Institute
17	APG's	Ambulatory Patient Groups
18	API	Application Program Interface
19	APM	Anatomical Pathology Module, part of an HIS
20	APT	Anatomic Pathology Test?
21	AR	Accounts Receivable
22	ARPA	Advanced Research Projects Agency
23	ARUP	Associated Regional and University Pathologists
24	ASCII	American Standard for Code Information Interchange
25	ASCP	American Society of Clinical Pathologists
26	ASTM	American Society for Testing and Materials
27	ATA	American Telemedicine Association, 512-480-2247
28	ATIS	Alliance for Telecommunications Industry Solutions
29	ATM	Asynchronous Transfer Mode, Automatic Teller Machine, Adobe Type Manager
30	AUI	Attachment Unit Interface, Ethernet transceiver cable between actual interface (computer) and the MAU
31	B-Channel	Bearer channel, ISDN channel with 64 kbps bandwidth (see PRI)
32	B/AR	Billings, Accounts Payable
33	BAI	Basic Access Interface, ISDN with two B and one D channels (2-64kbps, 1- 16 kbps), (2B+D)
34	BISA	Biomedical Informatics Society of Argentina
35	BLOB	Binary Large Object
36	BNC	A common type of quarter twist connector for coaxial cable.
37	BRI	Basic Rate Interface-16kbps ISDN Channel
38	BSF	Blood Systems Foundation, Scottsdale, AZ
39	BWH	Brigham and Women's Hospital
40	CA	Cancer Antigen
41	CAP	College of American Pathologists, Central Arizona Project
42	CBER	Center for Biologics Evaluation and Research
43	CBS	Common Basic Specification; Columbia Broadcasting Systems
44	CCBC	Council on Community Blood Centers
45	CCD	Charge Coupled Device, uses Photovoltaically generated packets of charge that are converted to pixels.
46	CCITT	Standards group now called ITU-T
47	CCOPE	Conjoint Committee On Pathology Enhancement
48	CDCP	Centers for Disease Control and Prevention
49	CDM	Common Data Model
50	CDR	Clinical Data Repository
51	CDRH	Center for Devices and Radiological Health
52	CEA	Carcino-Embroyonic Antigen
53	CEN	European Standards Group
54	CEN/TC 25	Working on spec similar to HL7. (CEN and HL7 coordinate)
55	CEO	Chief Executive Officer
56	CERC	Concurrent Engineering Research Center (CEEC) - WVU
57	CHCS	Composite Health Care System
58	CHI	Centre for Health Informatics, Wales
59	CHIME	College of Healthcare Information Management Executives
60	CHIN	Community Health Information Network
61	CHRP	Common Hardware Reference Platform, Multi-Platform operating system for computers
62	CIS	Clinical Information System
63	CLIA	Clinical Laboratory Improvement Amendment
64	CLIAC	Clinical Laboratory Improvement Advisory Committee
65	CLK	Clerk

Glossary of Telemedicine and Hospital Information Related Systems Acronyms; 11/1/96

66	CLUTS	Color Look Up TableS
67	COO	Chief Operating Officer
68	COPE	Combined Patient Experience, a laboratory medicine database
69	CORBA	Common Object Request Broker Architecture
70	COSI	Corporation for Open Standards International
71	COTS	Connection-Oriented Transport Service
72	COWS	Commission On World Standards, Pathology
73	CPE	Customer Premises Equipment
74	CPEP	Clinical Practice Expert Panel
75	CPR	Computer-based Patient Record: Coronary Pulmonary Resuscitation
76	CPT	Current Procedure Terminology
77	CPU	Central Processing Unit
78	CQI	Continuous Quality Improvement
79	CR	Computed Radiography
80	CSMA/CD	Carrier Sense Multiple Access with Collision Detection, Ethernet features
81	CT	Computed Tomography
82	D-channel	Delta-channel, ISDN channel with 16 kbps bandwidth (see BRI)
83	DDN	Defense Data Network
84	DEC	Digital Equipment Corporation
85	DG	Data General Corporation
86	DHCP	Decentralized Hospital Computer Program, used by DEC and CHCS
87	DHHS	Department of Health and Human Services
88	DICOM	Digital Imaging and Communications in Medicine
89	DINS	Digital Imaging Network Systems - Military term
90	DISA	Data Interchange Standards Association/ASC X12
91	DIX	DEC Intel Xerox, initial standard for Ethernet (now an IEEE 802.3 standard)
92	DMSSC	Defense Medical Systems Support Center
93	DNA	Deoxyribonucleic Acid Sp?
94	DOCking STATION	Doctor Operated Communication Kiosk Intelligently Networking Generalists Synergistically To All The Information Of Need
95	DoD	Department of Defense
96	DoH	Department of Health
97	DRAM	Dynamic Random Access Memory
98	DRG's	Diagnosis Related Groups
99	DSOs	Digital voice channels, used with ISDN
100	DTE	Data Terminal Equipment, usually a computer that interfaces with Ethernet
101	DTS	Dietetics
102	DVA	Department of Veterans Affairs
103	Dx	Diagnosis
104	EDI	Electronic Data Interchange
105	EDIFACT	Electronic Data Interchange for Administration, Commerce, and Transport
106	EGAD	Electronic Grant Application Development project, Dept. of Health and Human Services under NIH
107	ENR	Enterprise Network Roundtable, user group of ATM
108	EOC	Expense Operating Center ? ,an accounting term
109	EOQ	Economic Order Quantity
110	EPI	Enterprise Patient Index
111	EPROM	Electronically Programmable Read Only Memory
112	ESS	Executive Support System
113	FAQ	Frequently Asked Questions
114	FCC	Federal Communications Commission
115	FCS	Full Cover Slip
116	FDA	Federal Drug Administration
117	FDDI	Fiber Distributed Data Interface
118	FIFO	First In - First Out
119	FNA	Fine-Needle Aspiration
120	FOE	Fiber Optic Enclosure
121	FOIRL	Fiber Optic Inter-Repeater Link, used with Ethernet
122	FOMAU	Fiber Optic Medium Attachment Unit, transceiver for Ethernet
123	FTP	File Transfer Protocol
124	FYI	For Your Information
125	GAO	General Accounting Office
126	GATT	General Agreement for Tariff and Trade
127	GHNet	Global Health Net
128	GL	General Ledger
129	GNA	Global Network Academy
130	GNP	Gross National Product

Glossary of Telemedicine and Hospital Information Related Systems Acronyms; 11/1/96

131	Gopher	animated contraction of "go-for" looks for subject or words of interest on the NET
132	GP	General Practitioner
133	GPIP	General Purpose Image Processing
134	GPR	Graphical Patient Record
135	GRIPE	Group for Research in Pathology Education
136	GUI	Graphical User Interface
137	GYN	Gynecological
138	HAF	Hyperalimentation Fluids
139	HCFA	Health Care Financing Administration
140	HCIS	Health Care Information System
141	HCO	Health Care Organization
142	HCTG	Health Care Technology Group
143	HDTV	High Definition Television
144	HEDIS	Health Plan Employer Data and Information Set
145	HIMA	Health Industry Manufacturers Association
146	HIMSS	Healthcare Information and Management Systems Society
147	HIS	Hospital Information System, Health Information System
148	HISPP	Health Informatics Standards Planning Panel, formed by ANSI
149	HISS	Hospital Information Support System
150	HITS	Health Innovations in Technology Systems, yearly award given by the Henry Ford Health System
151	HL7	Health Level 7, Interface Standard
152	HMO	Health Maintenance Organization, Health Maintenance Group
153	HTML	Hyper Text Markup Language
154	IBM	International Business Machines
155	ICD	billing code used for various cases?
156	ICU	Intensive Care Unit
157	ID	Individual Identifier
158	IDN	Integrated Digital Network
159	IEC	Image Exchange Committee, developing Pathology extension to DICOM
160	IEEE	Institute of Electrical and Electronic Engineers
161	IHID	Inter Hospital Image Distribution
162	IIM	Institute for Information Management, Robert Morris College
163	ILCP	International Liaison Committee of Presidents, forum of English speaking pathologists
164	ILO	International Labor Organization
165	ILSG	International Lymphoma Study Group
166	IPA	Independent Physicians Association, or Independent Practice Association
167	ISA	International Standards Association, Instrumentation Society of America
168	ISAM	Indexed Sequential Access Method, (used with data bases)
169	ISDN	Integrated Services Digital Network
170	ISIS	Information System-Imaging System
171	ISO	International Standards Organization
172	IT	Information Technology
173	ITU-T	International Telecommunications Union-Telecommunications, sets ISDN standards
174	JAHIS	Japanese Association of Healthcare Information Systems Industry
175	JPEG	Joint Photographers Expert Group
176	JWG-CDM	Joint Working Group, Common Data Model
177	LAB	Laboratory
178	LAM	Lymphangioleiomyomatosis
179	LAN	Local Area Network
180	LANL	Los Alamos National Laboratory(ies)
181	LEOS	Low Earth Orbit Satellite
182	LIFO	Last In - First Out
183	LIS	Laboratory Information System
184	LM	Laboratory Module, part of an HIS
185	LOINC	Laboratory Observation Identifier Names and Codes
186	LOS	Length Of Stay
187	LSDA	Line Scan Diode Array, provides high resolution large image scanning capability
188	MAC	Medium Access Control, provides access when available from each Ethernet station
189	MAR	Medication Administration Record
190	MAU	Medium Attachment Unit, Transceiver for Ethernet that interfaces between computer and the medium.
191	MC	Medullary Carcinoma
192	MD	Medical Doctor
193	MDC	MUMPS Development Committee
194	MDF	MD Forms
195	MDI	Medium Dependent Interface, Ethernet hardware that connects directly interfaces to the medium.
196	MDIS	Medical Diagnostic Imaging Support system - used by Military.

197	MDL	MD Lookup
198	MDR	MD Retrieval
199	MEDIX	MEDical Data InterX, (X stands for exchange)
200	MGH	Massachusetts General Hospital
201	MHDI	Minnesota Health Data Institute
202	MICHI	Minnesota Institute for Community Health Information
203	MIS	Medical Information Systems, Management Information System
204	MPI	Master Patient Index
205	MRI	Magnetic Resonance Imaging
206	MRI	Medical Records Institute
207	MRN	Medical Record Number
208	MSDS	Message Standards Developers Subcommittee, health care message interchange stds, formed by HISPP
209	MTF	Medical Treatment Facilities - Military Term
210	MUMPS	Massachusetts (Gen. Hosp.) Utility Multi Programming System, Prog. Lang. used by SAIC & some Hosp.
211	NCI	National Cancer Institute
212	NCPDP	National Council of Prescription Drug Pharmacies, National Council of Prescription Drug Programs
213	NCQA	National Committee for Quality Assurance
214	NEMA	National Electrical Manufacturers Association
215	NET	Short for Internet
216	NHS	National Health Services
217	NIGMS	National Institute of General Medical Science
218	NIH	National Institutes of Health, Not Invented Here
219	NIHLB	National Institute of Heart, Lung and Blood
220	NII	National Information Infrastructure, goal to provide equable information services to all Americans
221	NII-HIN	National Information Infrastructure-Health Information Network
222	NINDS	National Institute for Neurological Disease and Stroke
223	NIOSH	National Institute of Occupational Safety and Health
224	NIST	National Institute of Standards and Technology
225	NLM	National Library of Medicine
226	NMF	Network Management Forum
227	NOS	Not Otherwise Specified
228	NPS	Non Printed Specifics
229	NRS	Nursing
230	NSF	National Science Foundation; National Standard Format, for health service claim entries
231	OBRA	the Omnibus Budget Reconciliation Act
232	ODA	Optical Disk Archiving system
233	ODJ	Optical Disk Jukebox, Optical media (platters) for high density digital storage
234	OLE	Object Linking and Embedding
235	OMG	Object Management Group, (responsible for CORBA standards)
236	OOT	Object Oriented Technologies, a Company - does CORBA; Out Of Town
237	OSHA	Occupational Safety and Health Administration
238	OSI	Open System Interconnection, seven layers of hierarchy
239	OT&E	Operational Test and Evaluation
240	PACS	Picture Archiving and Communications System - Used by Military
241	PAD	Patient Administration Department?
242	PAHO/WHO	Pan American Health Organization/World Health Organization
243	PALI	Pathologist Accelerated Laboratory Investigation
244	PAS	Patient Appointment Scheduling
245	PBXs	Private Branch Exchanges
246	PC	Personal Computer
247	PCI	Patient Care Inquiry, high speed buss that carries information in PC's and Power Macs
248	PCM	Personal Computer-Microscope, provides workstation features with digital images
249	PET	Positron Emission Tomography
250	PHO	Physician Hospital Organization
251	PHR	Pharmacy
252	PHS	Public Health Service
253	PM	Pagetoid Melanocytosis, upward discontinuous extension of melanocytes into the epidermis.
254	PMED	Portable Medical Entry Device
255	PO	Purchase Order
256	POE	PowerOpen Environment
257	PPO	Preferred Provider Organizations
258	PRI	Primary Rate Interface-ISDN 23 ea., 64 kbps channels + one 64-kbps D-channel
259	PRO	Peer Review Organization
260	PSA	Prostate-Specific Antigen
261	PtCT	Patient Care Technologies, Inc.
262	QA	Quality Assurance

Glossary of Telemedicine and Hospital Information Related Systems Acronyms; 11/1/96

263	QC	Quality Control
264	QTD	Quarter To Date
265	R&D	Research and Development
266	RAD	Radiology
267	RAID	Redundant Array of Inexpensive Disks
268	RBOCs	Regional Bell Operating Companies, the 7 Baby Bells
269	RBRVS	Resource-Based Relative Value Scale
270	REAL	Revised European-American Lymphoma classification
271	RGB	Red Green Blue, a TV full color generating scheme where all color is obtained by addition of R,G,B
272	RIS	Radiology Information System
273	RLA	Reference Laboratory Alliance
274	RM	Reference Model, Radiology Module, part of an HIS
275	RN, R.N.	Registered Nurse
276	RNA	Ribonucleic Acid
277	RTE	Remote Terminal Emulation
278	RUC	Relative value Update Committee, under AMA, reviews work relative values for effectiveness
279	SAIC	Science Applications International Company
280	SCSI	Small Computer Standard Interface, pronounced "scuzzi"
281	SDC	Surgical Day Care
282	SDOs	Standards Developing Organizations
283	SMTP	? , information protocol
284	SNMP	
285	SNOMED	Systematized Nomenclature of Medicine
286	SOW	Statement of Work
287	SQL	Structured Query Language
288	SRDRG's	Severity Refined Diagnosis Related Groups
289	SSN	Social Security Number
290	STARPAHC	Space Technology Applied to Rural Papago Advanced Health Care
291	T1	Communication lines with 1.54Mbt/sec transmission rate
292	TA	Terminal Adapter, interfaces with ISDN
293	TAMC	Tripler Army Medical Center
294	TCP/IP	Transfer Control Protocol, Internet Protocol
295	TDS	? , Total Dissolved Solids
296	TE	Terminal Equipment, devices using ISDN to transfer information
297	TELNET	Information Protocol
298	TIFF	Tagged Image File Format, Popular image file format for multiple platforms.
299	TM	Telemedicine
300	TQM	Total Quality Management
301	TRP	Technology Reinvestment Project
302	UHC	University Hospital Consortium
303	UR	Utilization Review
304	URL	Universal Resource Locator
305	USDHHS	United States Department of Health and Human Services - HCFA
306	VA	Veterans Administration
307	VAR	Value Added Reseller
308	VRAM	Video Random Access Memory
309	WAN	Wide Area Network
310	WASP	World Association of Societies of Pathology, Anatomical and Clinical, White Anglo-Saxon Protestant
311	WCP	World Congress of Pathology
312	WHIN	Wisconsin Health Information Network
313	WHO	World Health Organization
314	WOM	Write Only Memory, Useful for storing your mother-in-law's address
315	WORM	Write Once Read Many - Type of memory
316	WSU	Work Storage Unit, usually very high density digital storage may have fiber optic data transmission.
317	WTO	World Trade Organization
318	WWW	World Wide Web, graphical interface with hypertext used on the NET
319	XIWT	Cross-Industry Working Team, working on framework for the National Information Infrastructure
320	YTD	Year To Date